Technical Note

Public Works Canada | Travaux publics Canada

Solar Programs Office (613) 998-9817

No. 11: February 1983

Computer Program Support Provided by the Solar Programs Office

In order to facilitate the use of computer aids in solar system design, the Solar Programs Office (SPO) of Public Works Canada provides support services for a number of computer programs that are suitable for the design and evaluation of solar systems in the Canadian climate. These services are available to all Canadian solar system designers.

The following solar design aids are made available and supported by SPO on the Datacrown and Control Data service bureaus:

FCHART 4.1
VENTAIR 2.0
ENERPUB
ASTEP1

The SPO funds the provision, maintenance and storage of these programs on the service bureaus. Consultants pay their own computing costs. To gain access to the programs, contact Kevin Ford at SPO for information BEFORE contacting the service bureau to set up or modify an account.

Brief descriptions of these programs are attached.

Support provided by the SPO is defined as follows:

1) Program manuals are available on request from SPO (form attached).

2) Guidance is provided on the use and application of the programs and on the thermodynamic principles of the programs in relation to solar system design.

3) Guidance is provided on hardware configurations and access to the programs.

4) The programs are maintained by the SPO as the most up-to-date versions available, as recommended by the program authors or by SPO staff.

The SPO also uses the WATSUN Program and encourages others to do so. The National Research Council has funded the establishment of a WATSUN User's Service at the University of Waterloo, where the program originated. It is the responsibility of the User's Service to provide access to, and support for, the program. The SPO does not intend to duplicate the efforts of the WATSUN User's Service. For further information on access to WATSUN contact: L.R. Groves, (519) 885-6160. An information sheet on the use and application of WATSUN is attached.

For advice and assistance, contact:

Kevin Ford, Design Aids Engineer
Solar Programs Office
Public Works Canada
Sir Charles Tupper Building
Riverside Drive
OTTAWA, Ontario
K1A 0M2

Telephone: (613) 998-3641

Summary of Computer Programs Supported by SPO

1) **FCHART 4.1**

FCHART can be used for the analysis and design of solar heating systems and heat pump systems. Based on methods developed at the University of Wisconsin's Solar Energy Laboratory, the program features long-term thermal performance and life-cycle cost analysis, system optimization, and weather data handling capabilities. The program uses a month-by-month analysis. Weather data for 97 Canadian locations are built into the program. The user may input additional weather data. The program is interactive and provides tables of performance results.

See Technical Note #12 for a detailed summary of program enhancements for FCHART versions 3.0, 4.0 and 4.1.

2) **ENERPUB**

The ENERPUB computer program simulates the performance of liquid-based seasonal or short-term storage solar space heating systems with or without a heat pump. The program can also simulate the performance of a solar heating system used to heat oil in storage tanks. ENERPUB is not suitable for simulation of solar domestic hot water systems because of the restrictive heat exchanger models. Since performance is simulated for each hour, ENERPUB has the potential for greater accuracy than programs using monthly calculation procedures. Hourly weather data is available for 46 Canadian cities.

Several of the models in the ENERPUB program were adapted from WATSUN models with some enhancements over the WATSUN space heating programs:

- Stratified tank model for short-term or seasonal storage.
- Four possible heat pump locations.
- Inclusion of heat loss from the storage to the building, outdoors or ground.
- Inclusion of heat loss from collector and storage piping to building, outdoors or ground.

The attached diagrams show typical applications for which ENERPUB is suitable.

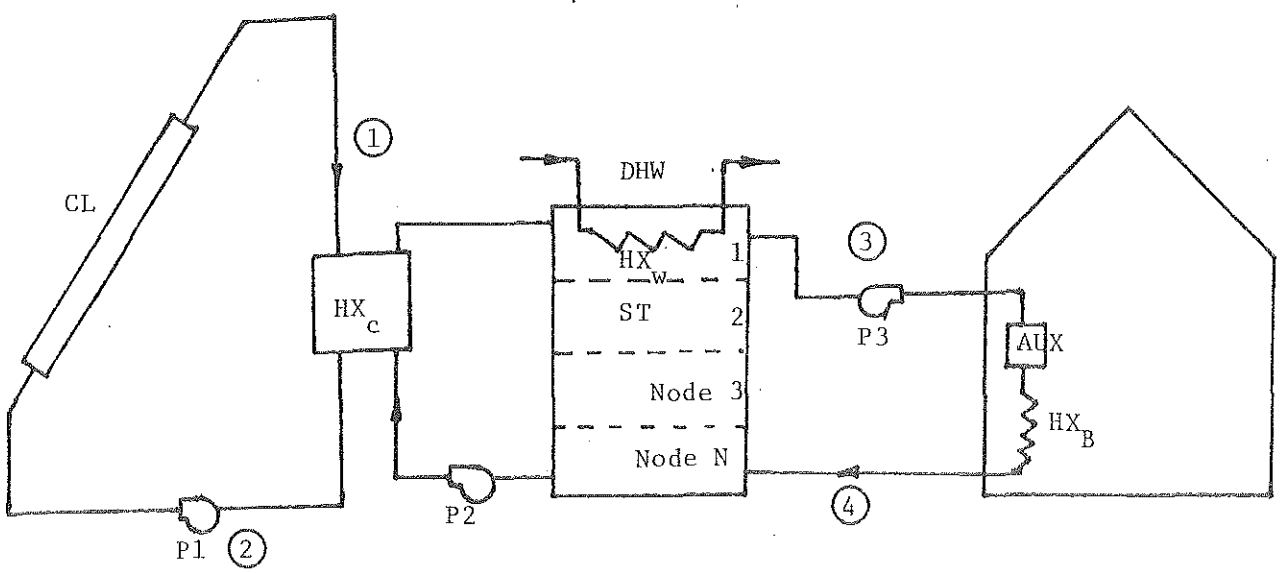


Figure 1: ENERPUB Application:
Solar Heating System Schematic - No Heat Pump - system type 0

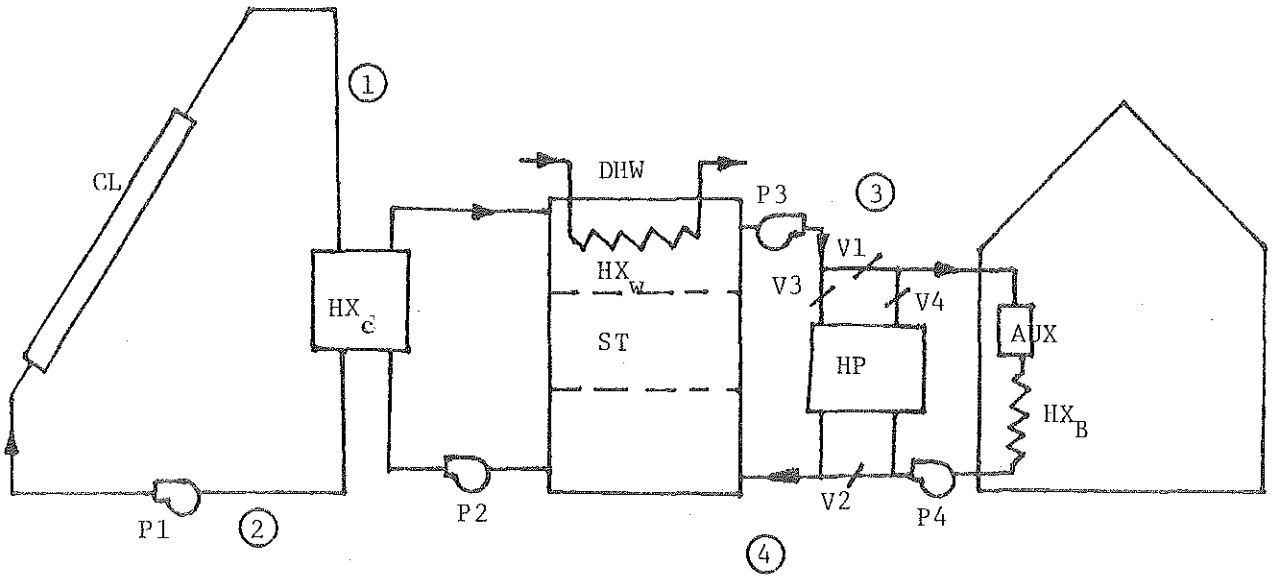


Figure 2: ENERPUB Application:
Solar Heating System Schematic - Heat Pump in Series with Solar Supply - system type 1

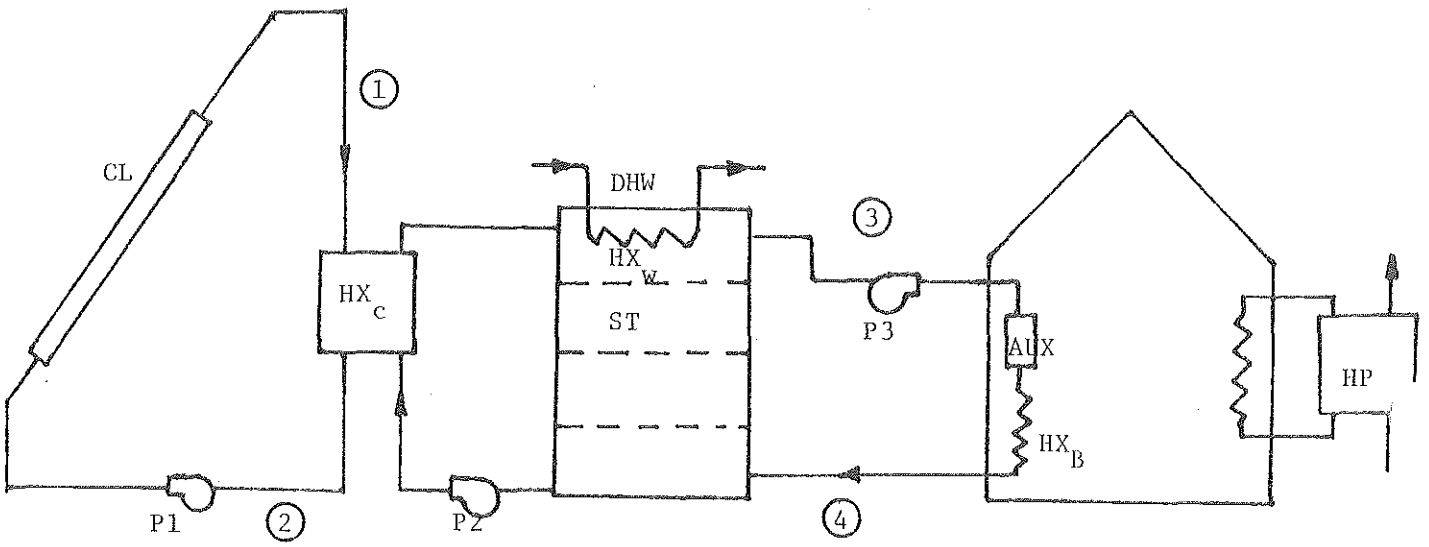


Figure 3: ENERPUB Application:
Solar Heating System Schematic - Heat Pump in Parallel with Solar Supply - system type 2

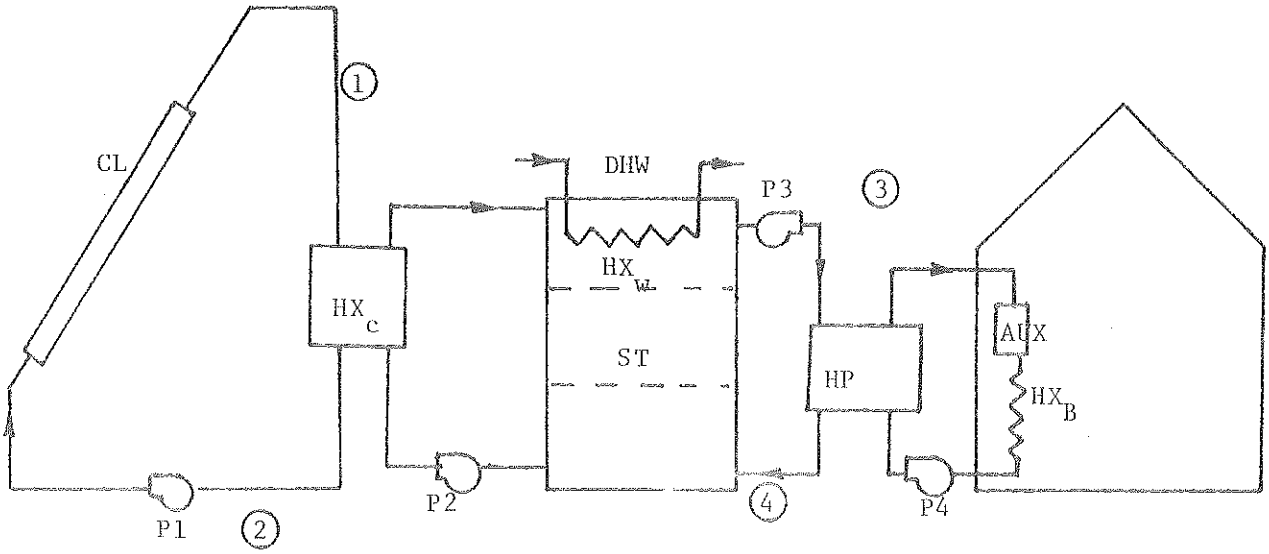


Figure 4: ENKRPUB Application:
Solar Heating System Schematic - Heat Pump Supply Only - system type 3

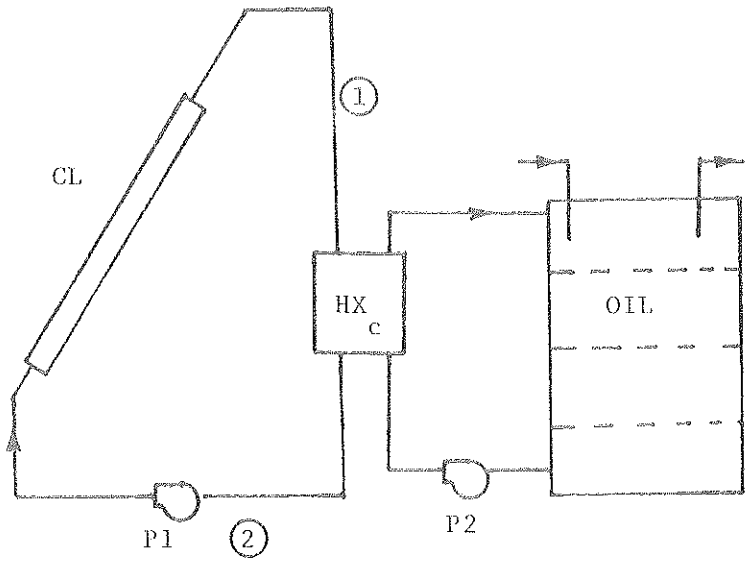
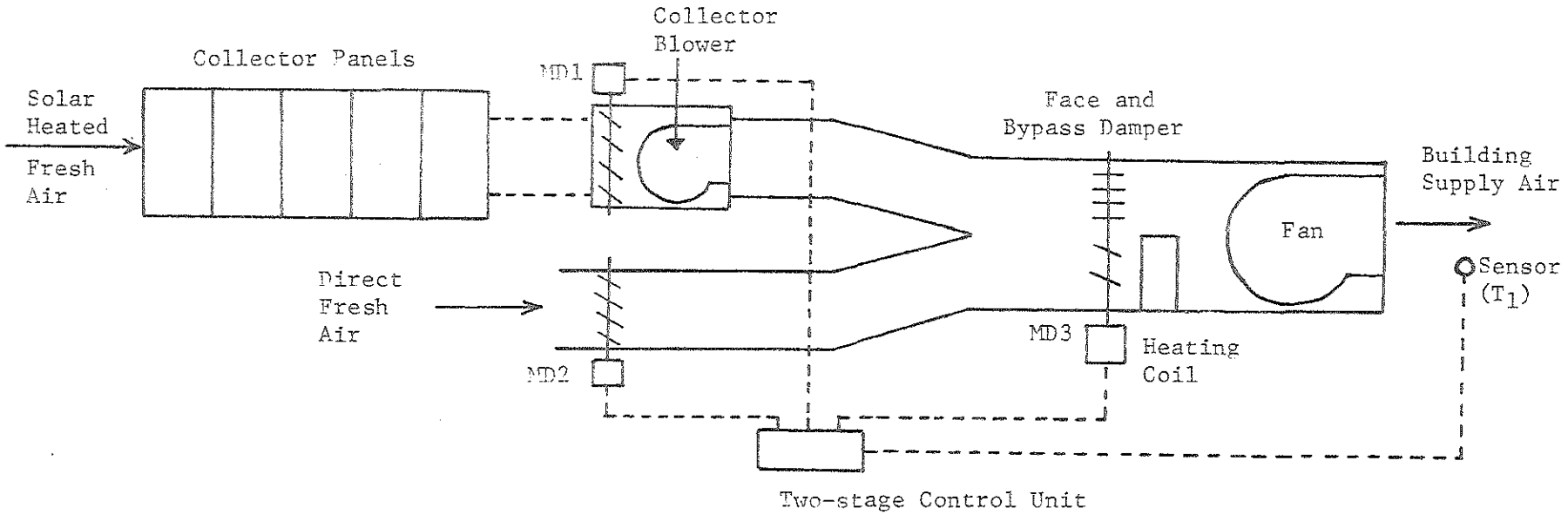


Figure 5: ENERPUB Application:
Oil Tank Heating System - system type 4

3) **VENTAIR 2.0**

The VENTAIR 2.0 computer program simulates the performance of air-based solar collectors used in industrial process or building ventilation preheat systems. The program can be used to simulate zero-storage systems with 100% ambient fresh air intake to the solar collectors. The program accepts data from all PUSH approved air-based collectors or from any parallel plate air-based collector or fibre matrix collector. Performance calculations are based on hourly simulations. Use of the program is restricted to applications for which the air demand is constant over the hour. For instance, a bathroom ventilation system operated by a light switch or short duration timer is not an appropriate application. Hourly weather data is available for 46 Canadian cities.

The attached diagram shows a typical application for which VENTAIR 2.0 is suitable.



SEQUENCE OF OPERATION

Stage	Tamb	Damper 1 (MD1)	Damper 2 (MD2)	Collector Blower	Damper 3 (MD3)	Heating Coil	T_1
1	T_{bg}	C	O	OFF	Bypass	OFF	T_{bg}
2	T_{bg}	O	O	ON	Bypass	OFF	T_{bg}
3	T_{bg}	O	C	ON	Bypass and Coil	ON	T_{bg}

T_{bg} is the desired inlet temperature to the building or process

Figure 6: VENTAIR Application: System Schematic

4) **ASTEP1**

ASTEP1 simulates the hourly performance of both liquid and air solar heating systems for space and service water heating. The program is primarily directed to the analysis of seasonal storage systems, although options are included to permit the simulation of short-term storage systems, a combined seasonal storage system and a short-term storage system.

ASTEP1 utilizes the newly expanded solar radiation database of the Canadian Atmospheric Environmental Services (AES), including pre-calculated radiation data for selected tilt angles. The program also allows the user to examine the effort of year-to-year weather changes on the performance of a specified design. A simplified but accurate method for calculation of heat losses for a buried seasonal thermal storage tank is included. Hourly weather data is available for 10 Canadian cities.

WATSUN

WATSUN is an interactive program for the thermodynamic and economic evaluation of solar system designs. It is based on hour-by-hour simulation and uses meteorological data for 52 Canadian locations. Fifteen modules are now available, from simple DHW systems to solar-assisted heat pump systems. The output includes the monthly and yearly energy consumption and a life-cycle economic analysis which compares the cost effectiveness of the solar heating system with a conventional reference heating system. WATSUN also provides several unique features such as specification of weekday/weekend and seasonal load profiles, various heat exchanger models, and detailed hourly printouts.

The following 14 system models are available:

1. DHW Domestic Hot Water System with Preheat Storage
2. DHWO Domestic Hot Water System without Storage
3. DHWA Domestic Hot Water System with Storage and Exchangers
4. L Liquid Based Solar Heating System
5. A Air Based Solar Heating System
6. LHPP Liquid Based SAHP System with HP in Parallel
7. AHPP Air Based SAHP System with HP in Parallel
8. LHPS Liquid Based SAHP System with HP in Series
9. AHPS Air Based SAHP System with HP in Series
10. LHPD Liquid Based SAHP with Dual Source HP
11. AHPD air Based SAHP System with Dual Source HP
12. LHPT Liquid Based SAHP System with Two Storages
13. HP Air-to-Air Heat Pump
14. ER Electric Resistance Heating System

However the Solar Programs Office has validated and approved only the first 5 models.

WATSUN MODELS

1. DHW

This model simulates a liquid-based solar DHW system with preheat tank such as that shown in Figure 7(a). The major components are collectors, storage tanks and auxiliary heater. Collected energy is stored in the preheat storage tank until required. When the heating demand cannot be met completely by the solar source, the auxiliary heater supplies the balance of the demand.

2. DHWO

This model simulates a liquid-based zero-storage solar system with no preheat tank as shown in Figure 7(b). The major components include collectors and auxiliary heater. Collected energy is passed directly to the auxiliary tank for use as needed. The auxiliary heater supplies the balance of the demand.

3. DHWA

This model simulates a liquid-based solar DHW system with preheat tank and heat exchangers as shown in Figure 7(c). The major components are collectors, storage tanks, heat exchanger(s) and auxiliary heater. Collected energy is stored in the preheat tank until required. When the demand cannot be met completely by the solar source, the auxiliary heater supplies the balance of the demand. Three types of exchanger are permitted - 1) external, 2) wraparound and 3) coil.

4. L

This model simulates a liquid-based solar heating system with a single tank serving both space and DHW loads as shown in Figure 7(d). The major components include collectors, storage tank, heat exchanger(s) and auxiliary heater. The DHW and space heating loads are served independently from a common storage tank. Collected energy is stored in the tank for use as needed. Auxiliary heaters supply the balance of the demand. Forced air distribution in the building is assumed.

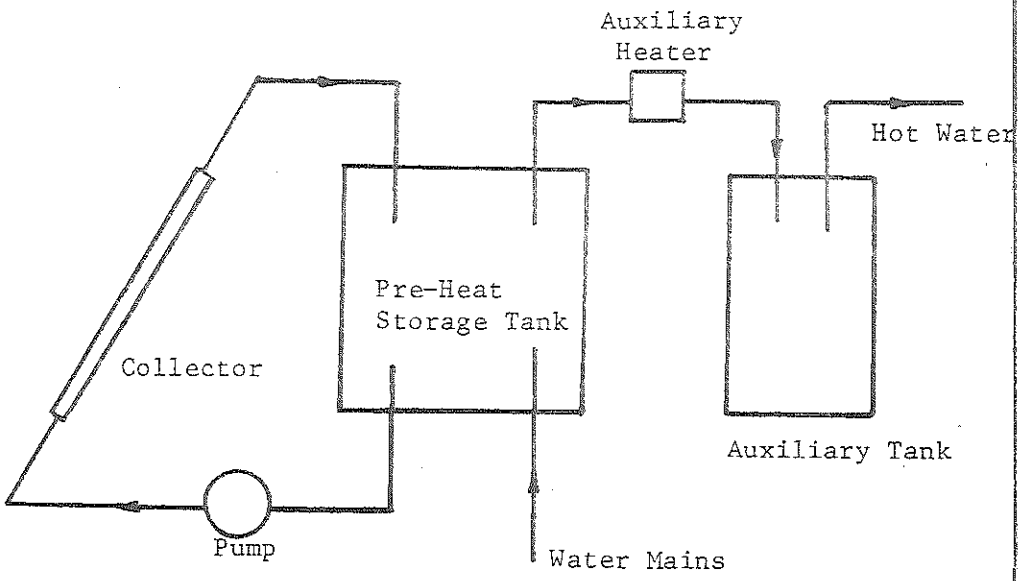


Figure 7a: WATSUN Application, Type DHW: DHW System with Preheat Tank

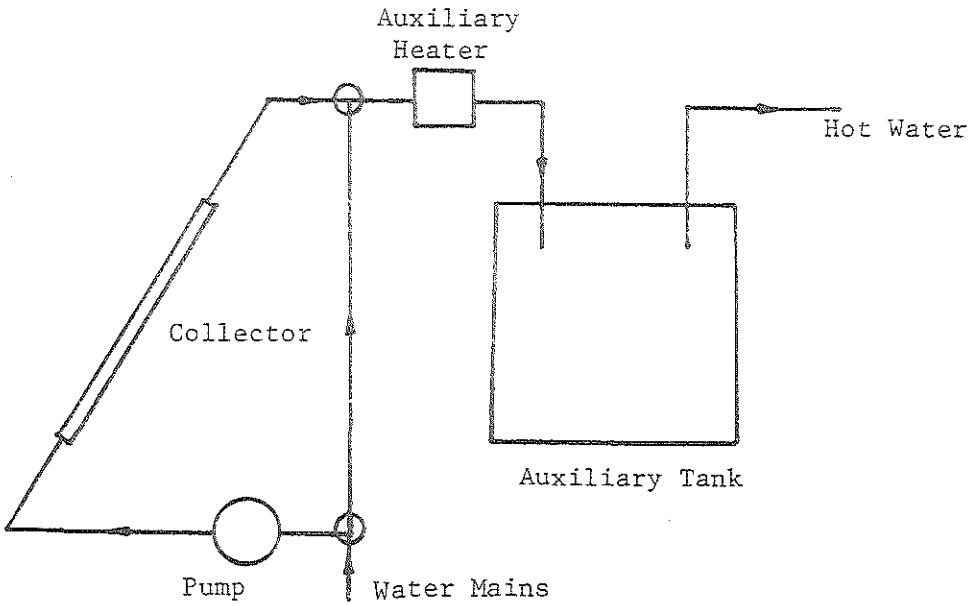


Figure 7b: WATSUN Application, Type DHWO: DHW Zero-storage System

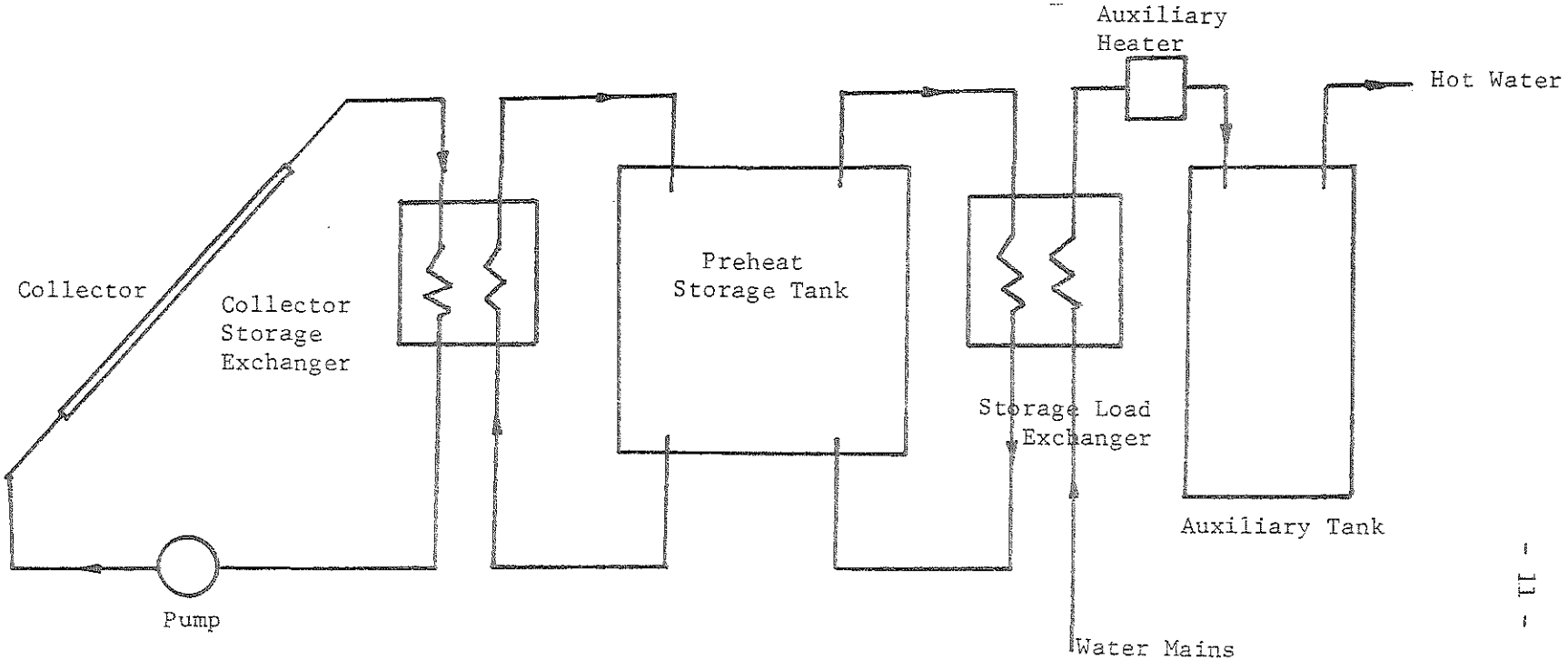


Figure 7c: WATSUN Application, Type DHWA: DHW System with Preheat Tank and Heat Exchangers

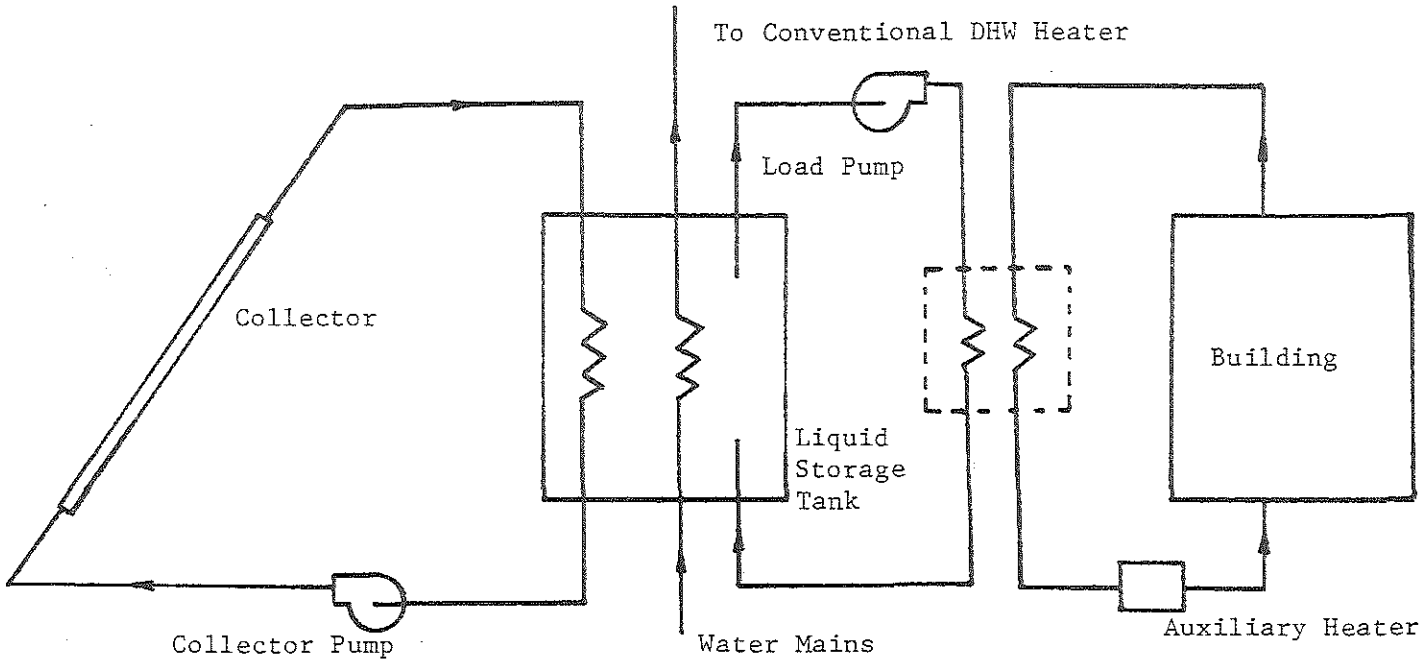


Figure 7d: WATSUN Application, Type L:
Liquid-based DHW and Space Heating System with Single Tank

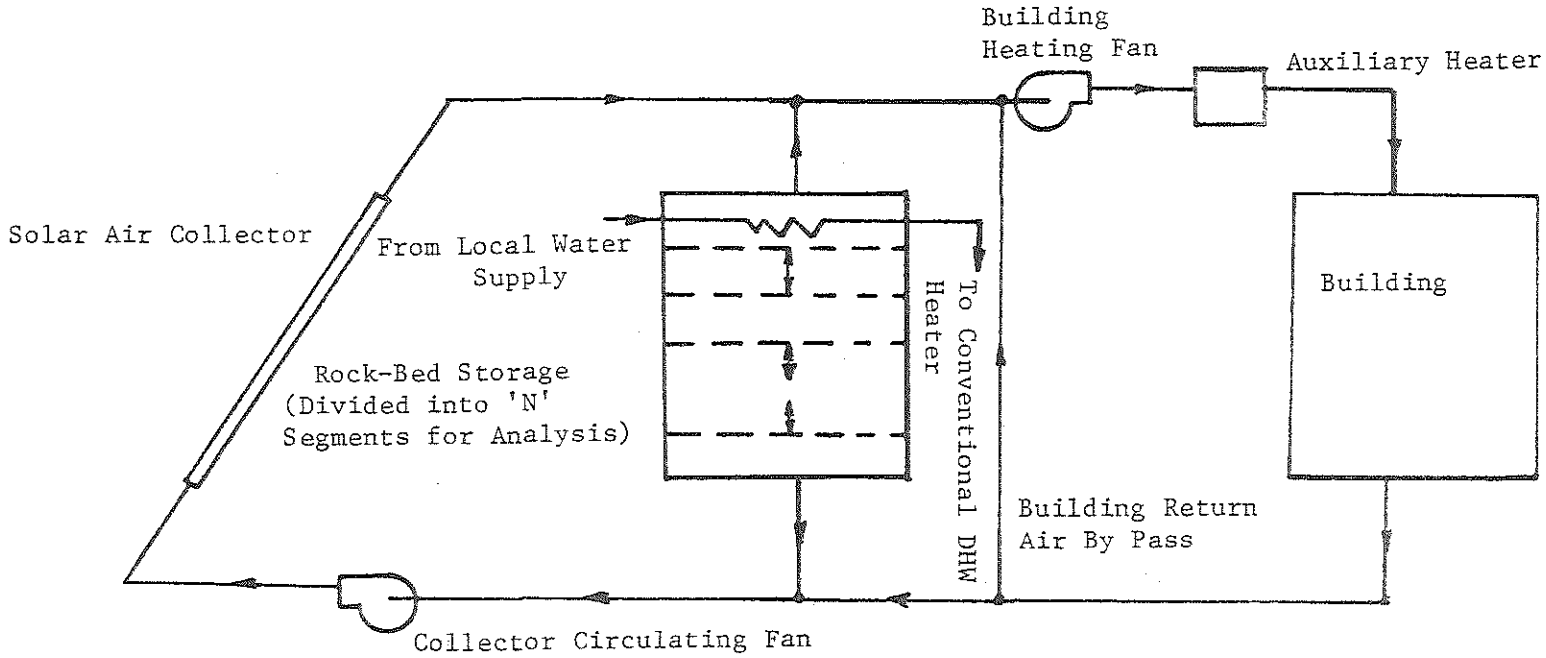


Figure 7e: WATSUN Application, Type A:
Air-based DHW and Space Heating System with Rock Bed Storage

5. A

This model simulates an air-based solar heating system for space and hot water heating of a residential building as shown in Figure 7(e). The major components are the collectors, rock bed storage and auxiliary heater. The heated air from the collectors is passed either through the storage or the building. If no collection is possible and there is a demand, energy is drawn from storage and supplemented by the auxiliary heater. A by-pass duct is used to moderate the temperature and maintain air flow. The storage can be stratified up to a maximum of 5 segments.

WATSUN User's Service

The WATSUN User's Service at the Univeristy of Waterloo provides the following support to users:

1) A user can set up an account to run WATSUN on the University of Waterloo computers, via a phone link.

2) Copies of the WATSUN program and manual can be purchased from the User's service.

3) Guidance is provided with respect to the thermodynamic models used for WATSUN.

Users may set up acounts to gain access to the program by contacting:

L.R. Groves
WATSUN User Service Facility
415 Phillip Street
WATERLOO, Ontario
N2L 3X2

Telephone: (519) 885-6160

ORDER FORM, COMPUTER PROGRAM MANUALS

I intend to use the following computer programs for the design and analysis of solar heating systems. Please send a manual for each of the programs checked and register me as a user of those programs.

Name: _____

Title: _____

Organization: _____

Address: _____

: _____

City: _____

Province: _____

Postal Code: _____

Telephone Number: ( ) _____

Computer Service Bureau Used: _____

Account Number: _____

☐ FCHART 4.1 (145 pages)

☐ ENERPUB (68 pages)

☐ VENTAIR 2.0 (50 pages)

☐ ASTEP1 (41 pages)

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Design Aids Engineer
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WATTSUN Reference Manual

Version 3.1

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Additional copies of WATTSUN Version 3.1
can be purchased from the
Washington State Energy Office.

For information, contact
John Doyle, 754-0745

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Introduction

Today's increased interest in energy efficient home construction has stimulated the demand for energy analysis tools which are quick and easy for the builder, designer, and code official to use, and which accurately reflect the importance of people, appliance, and solar gains in very well insulated buildings. WATTSUN is intended to be such a tool.

WATTSUN was developed by the Washington State Energy Office, Ecotope, and the Bonneville Power Administration. It was based on "The Model Conservation Standard Energy Budget Approach Handbook," prepared by Larry Palmiter and Richard Byers of Ecotope, Inc., with funding from the Bonneville Power Administration. The Handbook contains the coorelations for thousands of annual heating load simulations generated by the SUNDAY simulation program. SUNDAY was developed by Ecotope, Inc., and is used in evaluating Model Conservation Standards of the Northwest Power Planning Council. For more precise results, locations not listed, or buildings that are beyond the parameters of this program, users may wish to contact Ecotope, Inc., 2812 East Madison, Seattle, WA 98112, phone (206) 322-3753. WATTSUN was designed to assist the user in estimating the thermal component performance (UA/ft^2) and the space heat energy budget ($kWh/ft^2/yr$) of a single-family residence.[1]

WATTSUN can be used to comply with the thermal requirements of the Super Good Cents Program and relevant energy codes. In addition, WATTSUN 3.1 can provide a comparative economic analysis of two homes with different thermal characteristics and construction costs. This can be very useful when evaluating the cost effectiveness of proposed Super Good Cents homes with homes built to current energy codes or current practice.

It is very important that the user understand that the values are *relative* and not absolute. Actual heating and construction costs can, and most likely will, be different. The usefulness of this tool for evaluating building and heating costs is for bottom line comparisons — not actual costs or thermal performance.

Before attempting to run WATTSUN, see Chapter IV.

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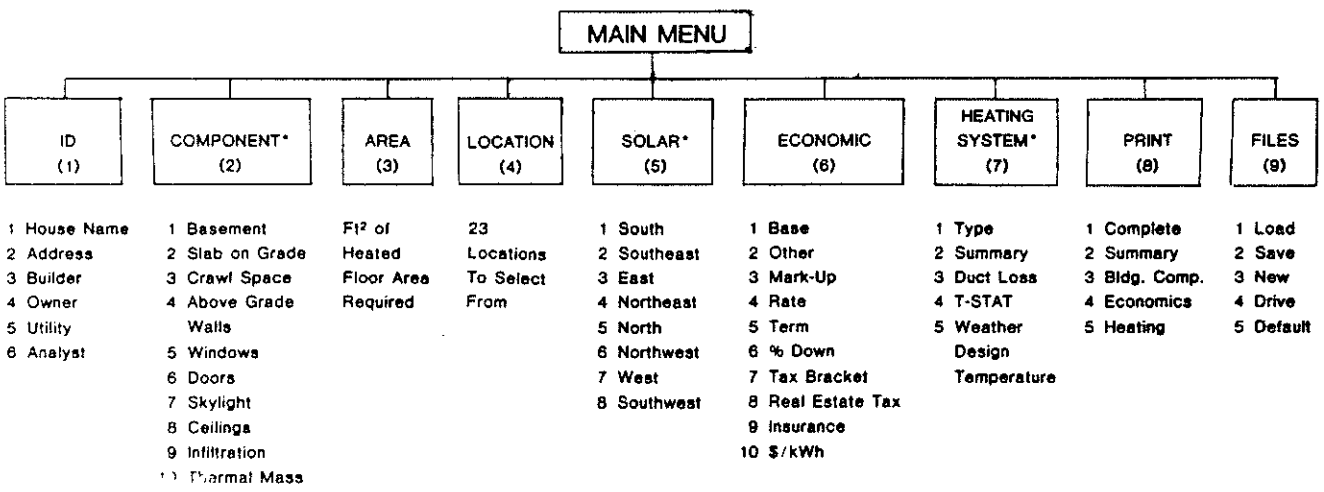
1 *Super Good Cents Reference Manual.* Oregon State University and Bonneville Power Administration. January 1985.

Overview of WATTSUN 3.1 Limitations and Parameters

Flow Chart of WATTSUN Menus

This flow chart provides an overview of the WATTSUN program. It shows the relationships of the various menus to one another. For instance, if the user is in the Main Menu and wishes to change the mortgage interest rate of the example run in Section IV, he or she would select (6) Economic Menu, and then select (4) to revise the mortgage rate. To select another menu, press (ESC) and the program will return to the Main Menu at which point the user can select another menu.



* Input for a *current* and a *proposed* home if economic analysis is required.

Thermal

The thermal analysis portion of WATTSUN consists of two main parts: 1) a menu driven building component description routine; and 2) an energy calculation routine.

The Component Menu of WATTSUN prompts the user for the types and areas of thermal components in a home. WATTSUN adds up the heat loss from all the specified building thermal components and calculates the heat loss coefficient (UA) in Btu/hr/°F. It then divides the UA by the ft^2 of heated floor area in order to provide the *component thermal performance* (UA/ft^2) as an option for Super Good Cents thermal compliance.

Another option is the *energy budget*. This thermal analysis routine of WATTSUN was derived from thousands of computer simulations and curve fit correlations that were developed by Ecotope for the Bonneville Power Administration. To calculate the energy budget, the user must specify the house location, heated floor area, glazing area, and thermal mass in addition to the Component Menu information. The energy budget ($kWh/ft^2/yr$) is defined as the number of kWh used to space heat a ft^2 of heated floor area in one year.

Location

Compliance with the Northwest Power Planning Council's Model Conservation Standards can be evaluated using:

Portland: (Zone 1, <6,000 HDD)
Spokane: (Zone 2, 6,000 ≥ HD ≤ 8,000)
Missoula: (Zone 3, >8,000 HDD)

The following cities' weather data can be run with WATTSUN. Otherwise use the location most typical of your area:

Astoria, OR
Billings, MT
Boise, ID
Cutbank, MT
Dillon, MT
Glasgow, MT
Great Falls, MT
Helena, MT
Lewiston, ID
Lewiston, MT
Medford, OR
Miles City, MT
Missoula, MT
North Bend, OR
Olympia, WA
Pocatello, ID
Portland, OR
Redmond, OR
Salem, OR
Seattle, WA
Spokane, WA
Whidbey Island, WA
Yakima, WA

House Size

WATTSUN will provide the most accurate results for heated floor areas of 850-3,350 ft^2 (in most cases this includes basements but not unheated garages).* The program will accept values from 500 ft^2 to 3,350 ft^2.

Glazing Area

The maximum glazing as a percentage of heated floor area is 20 percent.*

*WATTSUN will advise you when you are out of this range.

Thermal Mass

This Component Menu input is used for the "energy budget" calculation. WATTSUN will provide the most accurate results when the thermal mass level is greater than or equal to 3 Btu/F/ft² and less than or equal to 10 Btu/F/ft² of heated floor area. The program always assumes a minimum thermal mass of 3 Btu/°F/ft².*

Insulation Levels (UA/ft²)

Heat loss per square foot of floor area ranging from .1 to .8 Btu/ft² can be accurately evaluated. This range of insulation levels is found in new housing stock.*

Other

Thermostat settings are fixed at 65°F for Super Good Cents compliance only; internal gains (heat from people and appliances) are assumed to be 3,000 Btu/hr. Heating system efficiency is assumed to be 100 percent (including ductwork). *Thermostat settings, heating system efficiency, and heating duct heat loss can be changed by the user only when evaluating space heating use for the heating system economics portion of the program.*

Economics

Economic analysis can be an excellent marketing tool! It also allows the user to design the most efficient home for the least relative cost while still complying with the thermal requirements of Super Good Cents or relevant energy codes.

*WATTSUN will advise you when you are out of this range.

An economic comparison of two homes, *current* and *proposed*, can be accomplished if the home's heating system types, efficiencies, component insulation levels, areas, and cost differences* are entered in the Component Menu. WATTSUN does three economic analyses:

1. The life cycle cost (LCC) of the *current* and *proposed* homes is calculated. LCC is the total cost to purchase, maintain, and heat a home, including property taxes, insurance, and income tax interest deductions expressed in today's dollars and calculated over the home's expected life.

2. The first year's average monthly payments for the *current* and *proposed* home are calculated. This provides the user with information on the increase or decrease in first year cash flow. This information can be especially helpful to the lending institution which may evaluate the homeowner's ability to make house payments before proceeding with a loan.

3. You are allowed to analyze the various insulation strategies that you might wish to use on a particular house, comparing each option in terms of heat saved per dollar spent. With a fixed dollar budget for conservation features, you can spend the money first on those items that provide the greatest reduction in heat loss per dollar spent. Dividing the reduction in heat loss from *current* to *proposed* into the cost of upgrading the component yields the cost optimization ratio expressed as Cost/UA. The smaller this value, the better the option.

Note: It should be stressed that these are comparative costs and not actual costs.

*Cost differences, known as "incremental costs", are the additional costs associated with any comparison of alternatives, such as increased insulation or heating system efficiency. For a more complete explanation and reference table of "incremental costs", see Section V.

WATTSUN allows changes in economic parameters. There are certain assumed values, called "default" values, that WATTSUN will automatically use unless manually changed by the user while in the Economic Menu. Default values can be customized and saved as part of the default values associated with the default building file specified under the Files Menu in the WATTSUN program.

Parameters		Default
1	Base *(cost of home)*	$75,000
2	Other *(miscellaneous costs)*	$0
3	Mark-up *(on envelope and heating system)*	20%
4	Rate *(interest on loan)*	12%
5	Term *(length of loan)*	30 yrs.
6	Downpayment *(percentage)*	10%
7	Tax Bracket *(federal and state)*	30%
8	Real Estate Tax	2% of total cost
9	Insurance	1% of total cost
10	$/kWh *(cost of electricity)*	$.05/kWh

Assumed default values for real fuel cost escalation and consumer discount rates cannot be changed by the user. The values used in WATTSUN are as follows:

1	Consumer discount rate	10%/year
2	Real fuel cost escalation rate	3%/year

Getting Your Inputs Together

An Overview

Before running WATTSUN, you must determine *all* paths of heat loss from the home, the area (ft^2) of those paths, and the nominal insulation levels (insulation R-values only) in those paths. The paths of heat loss through various building components to consider are as follows:

1. Basements*
2. Slab on Grade*
3. Crawl Space
4. Above-Grade Walls
5. Windows
6. Doors
7. Skylights
8. Ceilings
9. Infiltration
10. Thermal Mass

* Record the linear footage (LF) of these components.

Things to Consider When Entering Areas and R-Values

1. Acquire your dimensions from the house plans and window/door schedules.
2. Always record outside dimensions.
3. Record the rough frame area of windows and doors available on window/door schedules.
4. Record all above-grade portions of below-grade walls as above-grade wall.

5. Use the linear footage (LF) of all below-grade wall but *not* the daylight basement wall.
6. Record the area of glass in each direction (do not include skylights).
7. Total heated floor area (ft^2) should include all heated floor area, such as heated basements, heated greenhouses, heated garages, etc.
8. Record (LF) of slab *on* grade and include the exposed portion of daylight basement slab.
9. Record (LF) of ductwork and furnace duct size in unheated space.
10. Record (ft^2) of above-grade exterior masonry walls including exterior fireplace walls and uninsulated above-grade basement walls.
11. *Acquire net wall area by subtracting windows and doors from gross wall areas of that component.*
12. Don't forget odd walls, band joist areas, and knee walls to attics/crawl spaces.

How to Get the Information You Need From a Blueprint

1. Measure and record the linear footage (LF) of exterior foundation wall or slab for each type of above-grade wall in home (include daylight basement walls).
2. Multiply the above values by the height of that type of above-grade building wall to get the gross wall area above-grade.
3. Determine and record the ft^2 of doors.
4. Determine and record the ft^2 of windows for each house direction (i.e., north, south, east, west) for each type of window (i.e., double glazed, triple glazed, etc.).
5. Subtract and record the doors and windows for each type of above-grade wall from the gross above-grade wall areas.

6. Measure and record the ft² of crawl space floor and roof area. *(Note: These will be the same for homes with flat ceilings only.)*
7. To calculate home volume, multiply the ceiling height by the total floor area and record. (Note: Add any additional cathedral ceiling volume to that number only if the cathedral ceiling is substantially leakier than the flat ceiling. For example, ceiling is car decking instead of sheetrock.)
8. Measure the ft² of heated wood floor area and record. Measure the ft² of slab floor area and record. Measure the number of gallons of water storage or ft² of additional thermal mass and record.
9. Measure and record the linear footage of below-grade basement wall (basement only).
10. Add windows in below-grade basement walls to window ft² in each direction.

Time-Saving Tips: Ask the builder to provide: a) window schedule with the manufacturer, model number, direction and ft² of each window included; b) door schedule with the manufacturer and model number; c) ft² of heated floor area.

Input Worksheets: An Example

The following worksheet examples have been completed for the example run in the next chapter. Blank worksheets for future use are included in Section IX.

The *Building Component Worksheet* has all the building component data.

The *Input Worksheet* has all the life cycle cost data for the economic inputs, heating system specifications, and the duct heat loss calculations.

Building Component Worksheet

HOUSE I.D.: EXAMPLE

MEAS NO	BUILDING COMPONENT	BUILDING STANDARD	COMPONENT DESCRIPTION	AREA/LF	COST TOTAL	INCREMENTAL COST $/UNIT
1	Below Grade Basement	Current				
		Proposed				
2	Slab On Grade	Current				
		Proposed				
3	Crawl Space	Current	R-11 BATT INSULATION	1400		
		Proposed	R-19 BATT INSULATION	1400		$0.12/ft²
4	Above Grade Walls	Current	R-11 BATT INSULATION 2x4 16" o.c.	1244		
		Proposed	R-19 BATT INSULATION 2x6, 24" O.C.	1244		$0.24/ft²
		Current				
		Proposed				
		Current				
		Proposed				
5	Windows	Current	1/4" DBL GLAZED METAL — TOTAL AREA 168; S 42, SE 42, N 42, W 42			
		Proposed	1/4" DBL GLAZED TIM W/STORM — 168; S 42, SE 42, N 42, W 42			$2.55
6	Exterior Doors	Current	SOLID CORE WOOD 1 3/4"	42		
		Proposed	FOAM CORE W/ THERMAL BREAK, R-14	42		$3.50
7	Skylights	Current				
		Proposed				
8	Ceiling	Current	R-30, 2x4, TRUSS STD	1050		
		Proposed	R-38, JOIST/TRUSS STD	1050		$0.12/ft²
		Current	R-30 VAULTED	409		
		Proposed	R-30 VAULTED	409		
9	Infiltration	Current	STD BUILDING PRACTICE	12,435		
		Proposed	PACKAGE 'B' W/ AAHE	12,435		$1700
0	Thermal Mass	Current	WOOD FRAME LIGHT CONSTRUCTION	1400		
		Proposed	WOOD FRAME LIGHT CONSTRUCTION	1400		

NOTES

SEO 4288

Input Worksheet

HOUSE I.D. EXAMPLE

MAIN MENU NO.		
1	1) House Identification:	EXAMPLE RANCH
	2) Address (site):	5001 MUD BAY Rd.
	3) Builder's Name:	TOM PENNY CONSTRUCTION
	4) Homeowner's Name:	JOE HOMEOWNER
	5) Utility's Name:	LOCAL UTILITY
	6) Analyst's Name:	ENERGY JOE
2	See Building Component Worksheet	
3	Heated Floor Area (including basement and upstairs):	1400 Ft²
4	Location (choose location from table in Section II):	PORTLAND
5	See Building Component Worksheet (window solar orientation)	

6 Economics	Current	Proposed
1) Base House Cost:	$ 77,000	$ 77,000
2) Other Costs:	$	$
3) Builder Mark-up:	20 %	20 %
4) Interest Rate:	12 %	12 %
5) Mortgage Term:	30 Yrs.	30 Yrs.
6) Down Payment:	10 %	10 %
7) Income Tax Bracket:	30 %	30 %
8) Real Estate Tax:	1 %	1 %
9) Insurance:	1 %	1 %
10) Cost Per kWh:	$ .05	$ .05

7	Current	Proposed
1) Heating Systems (describe):	BASEBOARD	BASEBOARD
2) Cost:	$ 1,000	$ 800
3) Ductwork in Unheated Space—		
Insulation R-values:		
Btu/hr F° (Table B):		
4) Indoor Thermostat Setpoint:	70 F°	70 F°
5) Outside Winter Design Temperature:	23 F°	25 F°

TABLE A

DUCT SIZE	DUCT FT² PER LF	INSULATION R-VALUE R-2	R-4	R-7	R-11
5" dia	1.31	0.66	0.33	0.19	0.12
6" dia	1.57	0.79	0.39	0.22	0.14
7" dia	1.83	0.92	0.46	0.26	0.17
8" dia	2.09	1.05	0.52	0.30	0.19
10" dia	2.62	1.31	0.66	0.37	0.24
12" dia	3.14	1.57	0.79	0.45	0.29
14" dia	3.66	1.83	0.92	0.52	0.33
8"x12"	4.67	2.34	1.17	0.67	0.42
10"x20"	5.0	2.50	1.25	0.71	0.45
20"x20"	6.67	3.34	1.67	0.95	0.61

TABLE B
Duct Heat Loss Calculation

DUCT RUN	LINEAL FEET		TABLE A VALUE	= HEAT LOSS BTU/HR F°
1		x		=
2		x		=
3		x		=
SUM LINES 1, 2, 3— TOTAL DUCT LOSS:				=

Refer to "Duct Heat Loss", Section IV, for instructions in the use of Tables A and B

WATTSUN 3.1

What You Will Need to Start

1. An IBM Personal Computer (PC, XT, or AT), Compaq, or other 100 percent compatible system.
2. 256K of random access memory (RAM).
3. Two 5-1/4" floppy disk drives (double-sided, double-density), or one hard disk and one 5-1/4" floppy disk drive.
4. Any 80-column dot matrix or letter-quality printer.
5. A diskette containing version 2.0 or greater of DOS (normally purchased along with your computer system).
6. The WATTSUN Master Disk which accompanies this manual.
7. Two blank floppy diskettes (for dual floppy systems only).

Dual Floppy Disk Systems

Before using the WATTSUN program, it is important for you to make a working copy of the original master disk, a working data disk, and a back-up data disk. *Never* use the original WATTSUN Master Disk for normal operation of the program. The steps required to make working copies are different for dual floppy and hard disk systems. The following are the instructions for making working disks for use on a dual floppy system.

Step 1: Label Your Blank Disks

Label the two disks as follows:

Disk 1: Working Program Disk: Drive A
Disk 2: Working Data Disk: Drive B

Step 2: Start Your System

Place your DOS disk in drive A (left side) and switch on the power to your computer. After about 30 seconds, your system should boot (load) DOS. Depending upon your system, you may be requested to enter today's date and the current military time; do so if requested. The DOS prompt **A>** should appear at the left side of your screen.

Step 3: Make a working copy of the WATTSUN Master Disk

To make a working copy of the WATTSUN Master Disk, you must first format the disk labeled Working Program Disk and copy your DOS software onto it. This can be done by running the FORMAT program from your DOS disk in drive A. Insert the Working Program Disk into drive B. Enter the command below and press the return key (large key between the normal typewriter keys and the numeric key pad which has an arrow symbol pointing downwards and then to the left). Enter:

FORMAT B:/S

The FORMAT program will begin with the following prompt:

Insert new disk for drive b:
and strike any key when ready

Press any key on the keyboard and the disk will be formatted and your DOS system will be copied onto it. While processing, the following messages and prompt will appear:

FORMATTING... FORMAT COMPLETE
System transferred
362496 bytes total disk space
40960 bytes used by system
321536 bytes available on disk

FORMAT ANOTHER (Y/N)?

Respond by typing N. The A> prompt will reappear at the left side of the screen. Now all the program and data files on the original WATTSUN Master Disk must be copied to the Working Program Disk. Remove the DOS disk from drive A and insert the original WATTSUN Master Disk in its place. The disk labeled Working Program Disk should still be in drive B. Copy the contents of the WATTSUN Master Disk in drive A to the Working Program Disk in drive B by typing the command below and pressing the return key. Enter:

COPY A:*.* B:/V

Files will be copied to the Working Program Disk in drive B. When the A> prompt reappears, remove the WATTSUN Master Disk from drive A and store it in a safe place. Remove the Working Program Disk from drive B. The Working Program Disk can store an additional 50 building files.

Step 4: Preparing the Working Data Disk

To format the Working Data Disk, put your DOS disk in drive A and the disk labeled Working Data Disk in drive B. Enter the following command, then press the return key:

FORMAT B:

When formatting of this disk is complete, the system will prompt with:

FORMAT ANOTHER (Y/N)?

Press N. Next, remove the DOS disk from drive A and replace it with the Working Program Disk. The Working Data Disk should still be in drive B. At the A> prompt, enter the command below and then press the return key:

COPY A:DEFAULT.* B:/V

The default files will be copied from drive A to drive B.

Running the WATTSUN Program

When running WATTSUN on a dual floppy disk system, always place the Working Program Disk in drive A and the Working Data Disk in drive B. The program can be started in one of three ways:

1. If your computer is off, turn it on and insert the Working Program Disk in drive A and the Working Data Disk in drive B. The Working Program Disk will automatically start it running.

2. If your computer is on, insert the Working Program Disk in drive A and Working Data Disk in drive B. When the prompt A> appears, enter the following command and press return:

   WATTSUN

3. If your computer is on, you can also start the program by resetting the system. Reset the system by inserting the Working Program Disk in drive A and the Working Data Disk in drive B, and then press the following three keys at the same time:

   (CTRL) (ALT) (DEL)

Hard Disk Systems

Step 1: Start Your System

Switch on the power to your computer. After about 30 seconds your system should boot (load) DOS. Depending on your system, you may be requested to enter today's date and current military time; do so if requested. The DOS C> prompt should appear at the left side of your screen.

Step 2: Making a WATTSUN Subdirectory

Subdirectories allow you to group related program files and data files together on your hard disk. To make a subdirectory for all the WATTSUN files, type the following command at the C>

prompt and press the return key (large key between the normal typewriter keys and the numeric key pad which has an arrow symbol pointing downwards and then to the left):

MKDIR\WATTSUN

Move to your newly created WATTSUN subdirectory by typing the following command and pressing the return key:

CD\WATTSUN

We are ready to copy the WATTSUN files from the original WATTSUN Master Disk to your hard disk.

Step 3: Copy WATTSUN to your hard disk

You should currently be in the WATTSUN subdirectory. Place the original WATTSUN Master Disk in drive A. To copy all the WATTSUN files to your hard disk, type the following command and press the return key.

COPY A:*.* C:

All the files on the Master Disk in drive A will be copied onto the hard disk. For the program to run smoothly from the hard disk, you need to change the location of the default file from drive A to drive C. To do this, enter:

WATTSUN (RET)

The message line at the bottom of the screen will ask if you would like help with the menus, enter:

N (RET)

Now press:

9

You are now in the file section of the program. To change the default file location, press:

5

Now to change the drive, press:

1

Enter:

C (RET)

To exit WATTSUN, press the (ESC) key 3 times. When you hear a tone, press:

E

Step 4: Running WATTSUN on your hard disk

To run WATTSUN you must first be in the WATTSUN subdirectory. If you are not, move there by typing the following command and press the return key:

CD\WATTSUN

Now to run WATTSUN, type the following command and press the return key:

WATTSUN

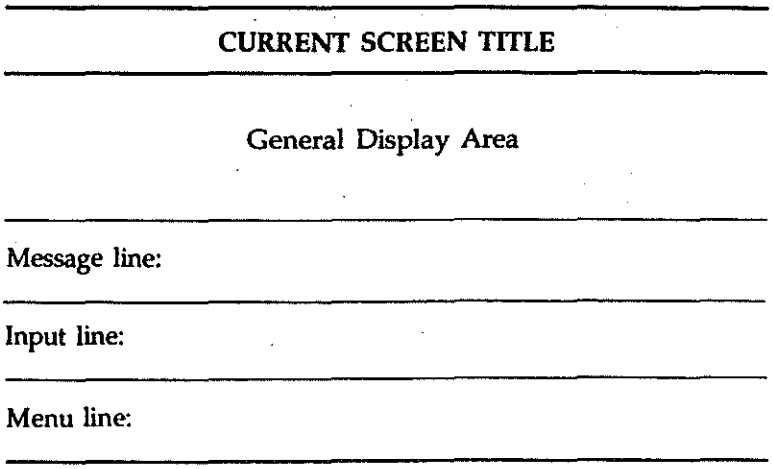
The program should start running.

The WATTSUN Screen Design

WATTSUN uses the screen to display a variety of information: descriptive or helpful *messages; prompts* which request you to supply information or answer questions via the keyboard; *menus* of selections which permit you to choose program functions and guide the operation of the program; and *data entry blanks* which provide a place for you to enter any information which WATTSUN requests of you. In general, you will notice that certain areas of the screen are reserved or used consistently for certain purposes. This use of the screen is "mapped" as shown below:

1. **Current screen title** — this tells you what menu you are in.
2. **General display area** — displays current building information.
3. **Message line** — "Action" line which tells you what to do next (gray and black).
4. **Input line** — gives you feedback on the current action you've chosen or prompts you to enter information (black and white).
5. **Menu line** — displays current choices available (gray and black).

The illustration below is a representation of the display screen.



Symbols Used in Our Example

It will be helpful to the user to understand the following typographic symbols for this chapter.

BOLD FACE print indicates what you should enter as a response to a prompt.

( ) indicates a single command key, such as:

(↵) graphic symbol for the return key (on your keyboard) is represented in this manual by (RET) carriage return.

(HOME) switches between "current" and "proposed."

(PG UP) page up to check first 10 options in Component Menu.

(PG DN) page down to check second 10 options in Component Menu.

(↑) scrolls up to previous component type.

(↓) scrolls down to next component type.

(*) deletes type, area, and cost.

(ESC) takes you back to previous screen.

(E) edit data (help mode only).

(←) backspace key.

(⇧) shift key.

(CAPS LOCK) cap lock key.

"Enter" means to type something on the keyboard. Entries are usually followed with a return key to proceed. "Press" means touch the pertinent key and WATTSUN will proceed.

Entering Data

Menu Selection. Select a number from the menu line corresponding to the menu for which data will be entered or edited.

Entering Data. Select a letter corresponding to the information to be entered or edited. Now, for a construction type, select a number from the general display area that corresponds to the construction type. To enter areas or incremental costs, select the appropriate letter corresponding to area or cost and then enter the areas or costs.

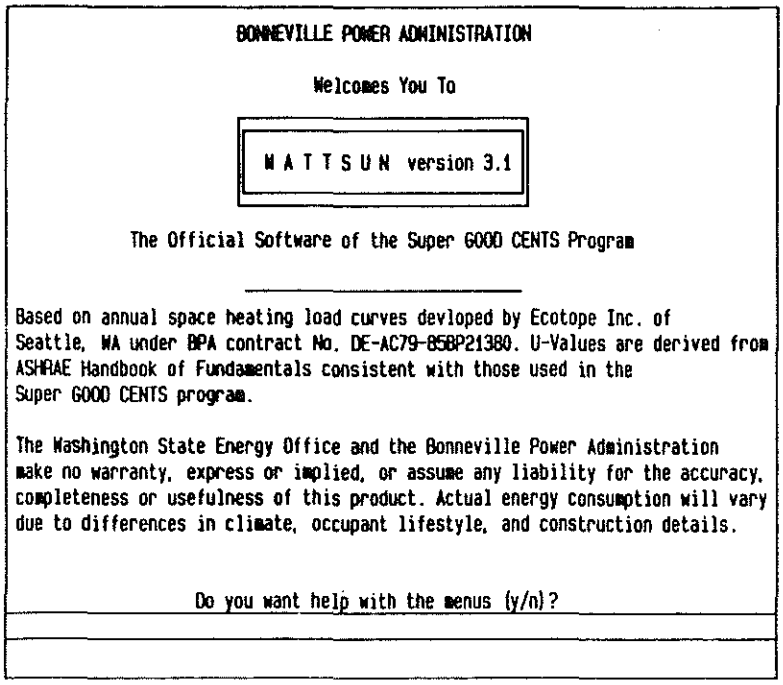
Help vs. No Help Runs

Shortly after starting up WATTSUN, you will be asked if you want help running WATTSUN. If you do want help, press Y when asked. Help provides additional feedback to the user to check that the current selection is desired. It also gives the user the opportunity to escape without affecting data or going to the next portion of the program. Running WATTSUN with help also requires you to enter E for edit prior to entering information in the Building Component Menu.

Note: When in doubt about what to do next, read the message line at the bottom of the screen to see what WATTSUN is asking for.

Start the WATTSUN program according to the instructions in the previous section.

You should see:


BONNEVILLE POWER ADMINISTRATION
Welcomes You To
M A T T S U N version 3.1
The Official Software of the Super GOOD CENTS Program
Based on annual space heating load curves devloped by Ecotope Inc. of Seattle, WA under BPA contract No. DE-AC79-85BP21380. U-Values are derived from ASHRAE Handbook of Fundamentals consistent with those used in the Super GOOD CENTS program.
The Washington State Energy Office and the Bonneville Power Administration make no warranty, express or implied, or assume any liability for the accuracy, completeness or usefulness of this product. Actual energy consumption will vary due to differences in climate, occupant lifestyle, and construction details.
Do you want help with the menus (y/n)?

The program asks you if you want help. Enter:

Y (RET)

After a short pause, you should see:

WATTSUN V3.1 MAIN MENU		
House ID : Council Prototype Ranch	Utility : Bonneville Power Admin	
House Site: 1002 NE Holladay	Analyst : Harris	
Builder : Master Builders	Location : Portland, OR	
Homeowner : Joe Regional Average	Floor Area : 1,350 ft2	
QUALIFICATION CRITERIA	Current	Proposed
Thermal Performance (Btu/ft2 of floor)	0.344	0.214
Energy Budget (kWh/ft2 of floor)	5.47	1.95
HEATING SYSTEM		
Heating System Size in kBtu/hr (kW)	28.5(8.5kW)	17.5(5.5kW)
Total Annual Auxiliary Space Heat (kWh)	8,822	3,023
ECONOMICS		
First Year Monthly PITI+Energy ($/mo)	$701.88	$685.47
30 Year Life Cycle Cost ($)	$88,448.14	$85,742.11
Press number of menu choice or <ESC> to quit		
1-I.D. 2-COMPONENT 3-AREA 4-LOCATION 5-SOLAR 6-ECON 7-HEAT SYS. 8-PRINT 9-FILE		

You should be in the Main Menu with information from the default home shown. You can edit this default file or you can create your own new file, as in the following example.

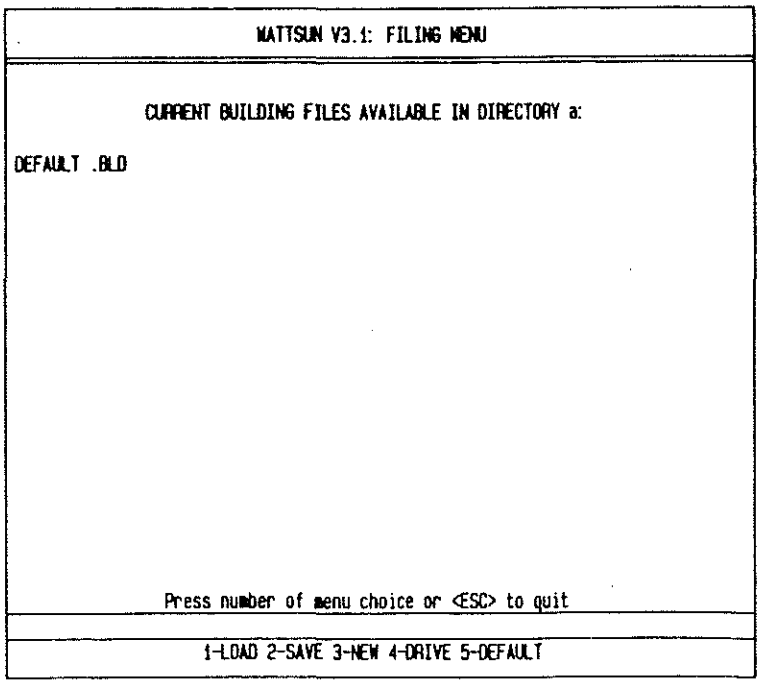
WATTSUN Example Run

Creating a New File

Let's start by creating a new file for the *current* and *proposed* example input forms enclosed. Creating a new file requires that you enter information in a pre-programmed sequence of events. While in the Main Menu, enter:

9 (RET)

You should see:


WATTSUN V3.1: FILING MENU
CURRENT BUILDING FILES AVAILABLE IN DIRECTORY a:
DEFAULT .BLD
Press number of menu choice or <ESC> to quit
1-LOAD 2-SAVE 3-NEW 4-DRIVE 5-DEFAULT

Now, to create a new file, enter:

3 (RET)

You'll now hear a tone. Press (RET) to confirm. You should see:

```
MATTSUN V3.1: BUILDING IDENTIFICATION MENU

House ID    :
House Site  :
Builder     :
Homeowner   :
Utility     : BONNEVILLE POWER ADMINISTRATION
Analyst     :

Press number of menu choice or <ESC> to quit

1-HOUSE IDENTIFICATION 2-ADDRESS 3-BUILDER 4-HOMEOWNER 5-UTILITY 6-ANALYST
```

Let's begin by entering the name of the house identification from our example. The house identification should describe the house type, i.e., ranch, basement, etc. Enter:

1 (RET)

You are asked to enter house I.D. Enter:

EXAMPLE RANCH (RET)

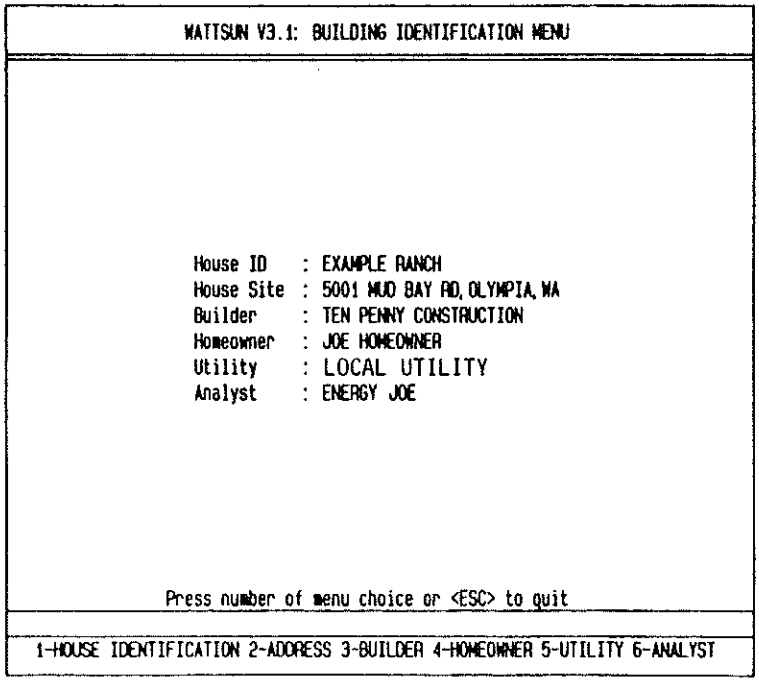
You are then asked to enter the house site. From our example, enter:

5001 MUD BAY RD OLYMPIA, WA (RET)

Now enter builder. Enter:

TEN PENNY CONSTRUCTION

Now enter homeowner, utility, and analyst from our example worksheet using the same procedure. When you reach the utility entry, you must press (5) to enter "LOCAL UTILITY". When complete, you should see:

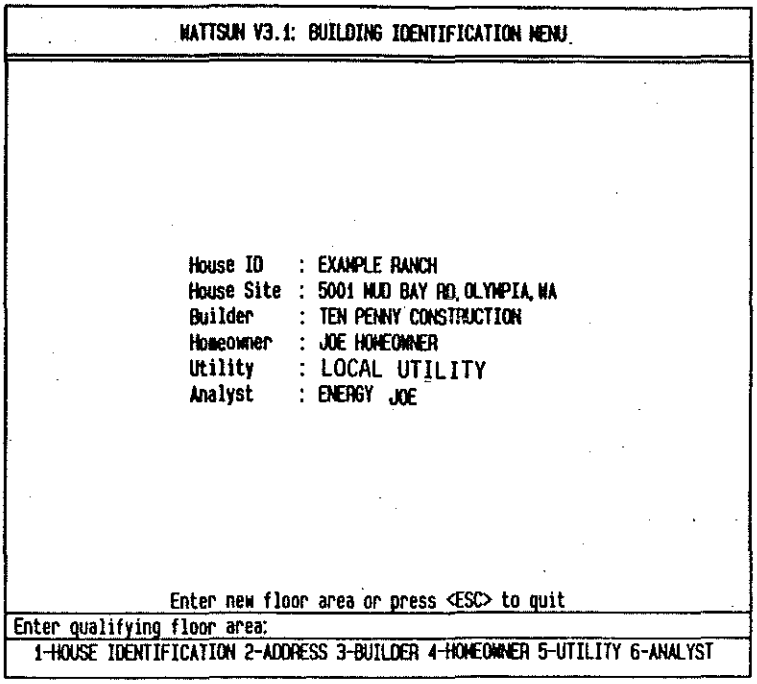

MATTSUN V3.1: BUILDING IDENTIFICATION MENU
House ID : EXAMPLE RANCH
House Site : 5001 MUD BAY RD, OLYMPIA, WA
Builder : TEN PENNY CONSTRUCTION
Homeowner : JOE HOMEOWNER
Utility : LOCAL UTILITY
Analyst : ENERGY JOE
Press number of menu choice or <ESC> to quit
1-HOUSE IDENTIFICATION 2-ADDRESS 3-BUILDER 4-HOMEOWNER 5-UTILITY 6-ANALYST

Note: In the "new" file sequence, the program automatically prompts you for the next I.D. entry. You can always go back and change any I.D. input by typing the number corresponding to the change and the new input and then return.

To input floor area, press:

(ESC)

You should see on the lower three lines:


MATTSUN V3.1: BUILDING IDENTIFICATION MENU
House ID : EXAMPLE RANCH
House Site : 5001 MUD BAY RD, OLYMPIA, WA
Builder : TEN PENNY CONSTRUCTION
Homeowner : JOE HOMEOWNER
Utility : LOCAL UTILITY
Analyst : ENERGY JOE
Enter new floor area or press <ESC> to quit
Enter qualifying floor area:
1-HOUSE IDENTIFICATION 2-ADDRESS 3-BUILDER 4-HOMEOWNER 5-UTILITY 6-ANALYST

You are then asked to enter the heated floor area from our example. Enter:

1400 (RET)

The next automatic step will take you to the Location Menu. You should see:

```
                    WATTSUN V3.1: LOCATION MENU

Super Good Cents Qualification can be evaluated using either:
                Portland (Zone 1, < 6000 HDD)
                Spokane  (Zone 2, 6000 < HDD < 8000)
                Missoula (Zone 3, >8000 HDD)
Otherwise use the location most typical of your area.
Heating degree days (base 65) are listed in () after the location.

 1 - Astoria, OR  (5248)          13 - Missoula, MT  (7839)
 2 - Billings, MT  (7049)         14 - Northbend, OR  (4661)
 3 - Boise, ID  (5802)            15 - Olympia, WA  (5719)
 4 - Cutbank, MT  (8700)          16 - Pocatello, ID  (7123)
 5 - Dillon, MT  (8370)           17 - Portland, OR  (4691)
 6 - Glasgow, MT  (8996)          18 - Redmond, OR  (6741)
 7 - Great Falls, MT  (7652)      19 - Salem, OR  (4974)
 8 - Helena, MT  (8196)           20 - Seattle, WA  (5121)
 9 - Lewiston, ID  (5436)         21 - Spokane, WA  (6892)
10 - Lewistown, MT  (8000)        22 - Whidbey Island, WA  (5609)
11 - Medford, OR  (4798)          23 - Yakima, WA  (6031)
12 - Miles City, MT  (7723)

          Enter number of new location or <ESC> to quit
Location number:
                    Current location is Portland, OR
```

You are asked to enter the number for your location. Our example is number 17. Enter:

17 (RET)

You should see PORTLAND, OR in the message line. Press:

(RET)

The program then loads the climate data you've specified. Once you've entered the location, the program moves into the Building Component Menu.

You should see:

MATTSUN V3.1: BUILDING COMPONENT MENU

COMPONENT	CURRENT UAc	PROPOSED UAp	(CURRENT-PROPOSED) UAc-UAp	INC. COST	COST/UA
1 BELOW GRADE WALL/FLOOR	0.0	0.0	0.0	$0.00	
2 SLAB ON GRADE	0.0	0.0	0.0	$0.00	
3 CRAWL SPACE FLOOR	0.0	0.0	0.0	$0.00	
4 ABOVE GRADE WALL	0.0	0.0	0.0	$0.00	
5 WINDOW	0.0	0.0	0.0	$0.00	
6 DOOR	0.0	0.0	0.0	$0.00	
7 SKYLIGHT	0.0	0.0	0.0	$0.00	
8 CEILING	0.0	0.0	0.0	$0.00	
9 AIR LEAKAGE CONTROL	0.0	0.0	0.0	$0.00	
0 THERMAL MASS	0.0	0.0		$0.00	
TOTALS:	0.0	0.0	0.0	$0.00	0.0$/Btu

QUALIFICATION CRITERIA	Current	Proposed
Thermal Performance (Btu/ft2 floor)	0.000	0.000
Energy Budget (kWh/ft2 of floor)	0.00	0.00

Press number of menu choice or <ESC> to quit

1-BASMNT 2-SLAB 3-CRWLSPC 4-WALL 5-WNDOW 6-DOOR 7-SKYLIT 8-CEILNG 9-INF 0-MASS

You should now be in the Building Component Menu. You can always get into the Building Component Menu by typing number 2 while in the Main Menu.

Remember that if you want to do an economic analysis, you will need to enter information on both the current and proposed home. If you are checking compliance with Super Good Cents, or relevant energy codes, you need only to enter that home's insulation levels and areas as the current home. For each component, 10 different construction type components can be entered.

Economic optimizations can be done by evaluating the $/UA column in the Building Component Menu. The lower the value, the better the investment. Let's begin by entering the building component information from our example worksheet. Since the components are listed "from the ground up" in the same way you would build a home, let's start with the Crawl Space Menu. Enter:

3 (RET)

You should see:

```
                    WATTSUN V3.1: MENU OF CRAWL SPACE FLOORS

Number     Construction Type                              U-Value  (Btu/ft2-Fh)
 1         R-11 Under Floor                                  .057
 2         R-19 Under Floor                                  .041
 3         R-25 Under Floor                                  .036
 4         R-30 Under Floor                                  .031
 5         OTHER                                             0

     Press <PgDn> to view next menu page or <PgUp> to view previous page

CRAWL SPACE FLOOR No. 1      U-Value     Area    Cost/ft2    UA   Total Cost
      Construction Type      Btu/ft2-Fh  ft2     $/ft2   Btu/F-hr
curr:                          0.000      0.0     $0.00      0.0    $0.00
prop:                          0.000      0.0     $0.00      0.0    $0.00

SUMMARY FOR CRAWL SPACE FLOOR:        No. of Entries    Total UA    Total Cost
                              current :       1             0.0        $0.00
                              proposed:       1             0.0        $0.00

     Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit
```

From our example worksheets, we have a *current* home with 1,400 ft² or R-11, and a *proposed* home with 1,400 ft of R-19. Let's edit by pressing:

(E)

You can change the following parameters with these commands:

Command	Parameter
(T)	Component insulation levels
(A)	Component insulation area
(C)	Incremental costs of insulation
(*)	Delete information

You should see:

```
                    MATTSUN V3.1: MENU OF CRAWL SPACE FLOORS

Number     Construction Type                              U-Value  (Btu/ft2-Fh)
 1         R-11 Under Floor                                  .057
 2         R-19 Under Floor                                  .041
 3         R-25 Under Floor                                  .036
 4         R-30 Under Floor                                  .031
 5         OTHER                                             0

     Press <PgDn> to view next menu page or <PgUp> to view previous page

CRAWL SPACE FLOOR No. 1        U-Value     Area    Cost/ft2    UA   Total Cost
      Construction Type        Btu/ft2-Fh  ft2      $/ft2   Btu/F-hr
curr:                            0.000      0.0     $0.00       0.0    $0.00
prop:                            0.000      0.0     $0.00       0.0    $0.00
 Press <T> for const. type; <A> for area; <C>ost or <*> to delete      CURRENT


    Press <↑><↓> to scroll comp.; <HOME> to change case; <ESC> to quit
```

You should see the word *current* or *proposed* flashing on the right side of the screen. This indicates where your information will be entered. The (HOME) key allows you to switch back and forth between *current* and *proposed*. After completing *current*, the program will automatically switch to *proposed*.

To enter component type for the *current* home, check to see that *current* is flashing on the screen. If *proposed* is flashing, press (HOME). When *current* is flashing, press:

T

Enter the number corresponding to the R-11 insulation from the "general display area" for the *current* home. Enter:

1 (RET)

The program then asks you for area. Enter:

1400 (RET)

You should see:

```
                    WATTSUN V3.1: MENU OF CRAWL SPACE FLOORS

Number     Construction Type                              U-Value  (Btu/ft2-Fh)
 1         R-11 Under Floor                                  .057
 2         R-19 Under Floor                                  .041
 3         R-25 Under Floor                                  .036
 4         R-30 Under Floor                                  .031
 5         OTHER                                             0

      Press <PgDn> to view next menu page or <PgUp> to view previous page

CRAWL SPACE FLOOR No. 1          U-Value     Area    Cost/ft2    UA   Total Cost
      Construction Type          Btu/ft2-Fh  ft2      $/ft2   Btu/F-hr
curr: R-11 Under Floor             0.057    1400.0    $0.00      79.8    $0.00
prop: R-11 Under Floor             0.057    1400.0    $0.00      79.8    $0.00
 Press <T> for const. type; <A> for area; <C>ost or <K> to delete      PROPOSED


   Press <↑><↓> to scroll comp.; <HOME> to change case; <ESC> to quit
```

Notice that the current home has been automatically entered as the *proposed* case, and *proposed* is now flashing. This means we only have to change the *proposed* type and specify the 12 cents/ft² costs from R-11 to R-19. To enter the R-19 as *proposed*, check that *proposed* is flashing and press:

(T)

2 (RET)

To record the costs, enter:

(C)

.12 (RET)

(ESC)

You should see:

MATTSUN V3.1: MENU OF CRAWL SPACE FLOORS

Number	Construction Type	U-Value (Btu/ft2-Fh)
1	R-11 Under Floor	.057
2	R-19 Under Floor	.041
3	R-25 Under Floor	.036
4	R-30 Under Floor	.031
5	OTHER	0

Press <PgDn> to view next menu page or <PgUp> to view previous page

CRAWL SPACE FLOOR No. 1	U-Value	Area	Cost/ft2	UA	Total Cost
Construction Type	Btu/ft2-Fh	ft2	$/ft2	Btu/F-hr	
curr: R-11 Under Floor	0.057	1400.0	$0.00	79.8	$0.00
prop: R-19 Under Floor	0.041	1400.0	$0.12	57.4	$168.00

SUMMARY FOR CRAWL SPACE FLOOR:	No of Entries	Total UA	Total Cost
current :	1	79.8	$0.00
proposed:	1	57.4	$168.00

Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit

Press:

(ESC)

You should see:

WATTSUN V3.1: BUILDING COMPONENT MENU

COMPONENT	CURRENT UAc	PROPOSED UAp	(CURRENT-PROPOSED) UAc-UAp	INC. COST	COST/UA
1 BELOW GRADE WALL/FLOOR	0.0	0.0	0.0	$0.00	
2 SLAB ON GRADE	0.0	0.0	0.0	$0.00	
3 CRAWL SPACE FLOOR	79.8	57.4	22.4	$168.00	7.5$/Btu
4 ABOVE GRADE WALL	0.0	0.0	0.0	$0.00	
5 WINDOW	0.0	0.0	0.0	$0.00	
6 DOOR	0.0	0.0	0.0	$0.00	
7 SKYLIGHT	0.0	0.0	0.0	$0.00	
8 CEILING	0.0	0.0	0.0	$0.00	
9 AIR LEAKAGE CONTROL	0.0	0.0	0.0	$0.00	
0 THERMAL MASS	0.0	0.0		$0.00	
TOTALS:	79.8	57.4	22.4	$168.00	7.5$/Btu

QUALIFICATION CRITERIA	Current	Proposed
Thermal Performance (Btu/ft2 floor)	0.057	0.041
Energy Budget (kWh/ft2 of floor)	0.00	0.00

Press number of menu choice or <ESC> to quit

1-BASMNT 2-SLAB 3-CRWLSPC 4-WALL 5-WNDOW 6-DOOR 7-SKYLIT 8-CEILNG 9-INF 0-MASS

Now let's enter above-grade walls. Enter:

4 (RET)

You should see:

```
                    WATTSUN V3.1: MENU OF ABOVE GRADE WALLS

Number     Construction Type                              U-Value (Btu/ft2-Fh)
 1         2x4 R-11 Std                                      .082
 2         2x4 Std R-13+0.5 in Iso                           .063
 3         2x4 Adv R-13+0.5 in Iso                           .06
 4         2x4 Std R-13+1.0 in Iso                           .051
 5         2x4 Adv R-13+1.0 in Iso                           .049
 6         2x6 R-19 Batt Std.                                .064
 7         2x6 R-19 Batt Adv.                                .057
 8         2x6 R-22 Batt Std.                                .059
 9         2x6 R-22 Batt Adv.                                .055
 10        2x6 Std R-19+1in.Ext.PS                           .046
     Press <PgDn> to view next menu page or <PgUp> to view previous page

ABOVE GRADE WALL No. 1          U-Value     Area   Cost/ft2    UA   Total Cost
     Construction Type          Btu/ft2-Fh  ft2    $/ft2    Btu/F-hr
curr:                             0.000      0.0    $0.00      0.0    $0.00
prop:                             0.000      0.0    $0.00      0.0    $0.00

SUMMARY FOR ABOVE GRADE WALL:          No. of Entries    Total UA    Total Cost
                               current :       1            0.0        $0.00
                               proposed:       1            0.0        $0.00

    Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit
```

To enter the wall information for current and proposed from our example, enter:

(E) [Check to see that *current* is flashing.]

(T)

1 (RET)

1244 (RET)

(T)

7 (RET)

(C)

.24 (RET)

(ESC)

You should see:

```
                    NATTSUN V3.1: MENU OF ABOVE GRADE WALLS

Number     Construction Type                                U-Value  (Btu/ft2-Fh)
 1         2x4 R-11 Std                                        .082
 2         2x4 Std R-13+0.5 in Iso                             .063
 3         2x4 Adv R-13+0.5 in Iso                             .06
 4         2x4 Std R-13+1.0 in Iso                             .051
 5         2x4 Adv R-13+1.0 in Iso                             .049
 6         2x6 R-19 Batt Std.                                  .064
 7         2x6 R-19 Batt Adv.                                  .057
 8         2x6 R-22 Batt Std.                                  .059
 9         2x6 R-22 Batt Adv.                                  .055
 10        2x6 Std R-19+1in.Ext.PS                             .046
    Press <PgDn> to view next menu page or <PgUp> to view previous page

ABOVE GRADE WALL No. 1          U-Value     Area    Cost/ft2    UA   Total Cost
     Construction Type          Btu/ft2-Fh  ft2     $/ft2    Btu/F-hr
curr: 2x4 R-11 Std                0.082    1244.0   $0.00      102.0   $0.00
prop: 2x6 R-19 Batt Adv.          0.057    1244.0   $0.24       70.9   $298.56

SUMMARY FOR ABOVE GRADE WALL:          No. of Entries    Total UA    Total Cost
                              current :        1           102.0        $0.00
                              proposed:        1            70.9      $298.56

    Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit
```

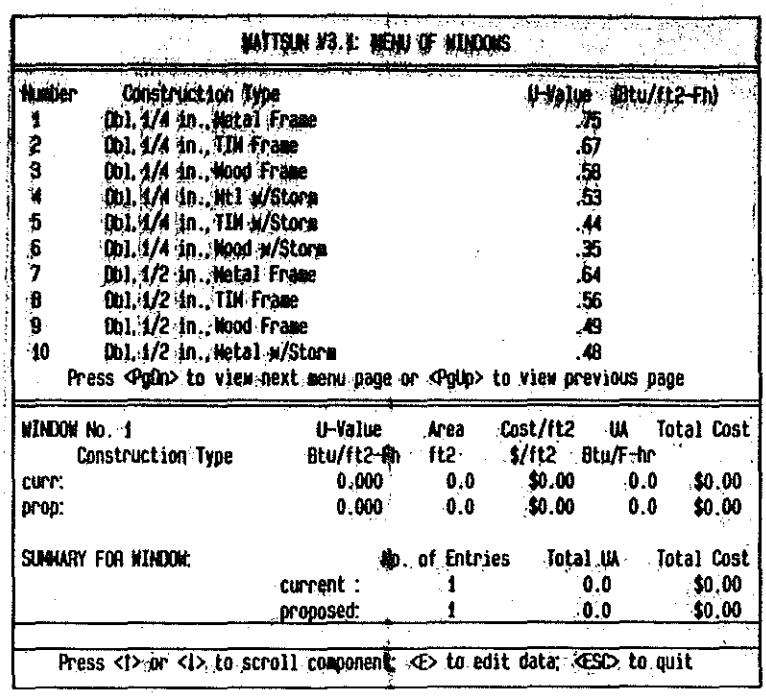
To enter another component, enter:

(ESC)

Now you are in the Building Component Menu. Now let's enter windows. Enter:

5 (RET)

You should see:



```
                    WATTSUN V3.1: MENU OF WINDOWS

Number    Construction Type                                U-Value  (Btu/ft2-Fh)
  1       Dbl, 1/4 in., Metal Frame                          .75
  2       Dbl, 1/4 in., TIM Frame                            .67
  3       Dbl, 1/4 in., Wood Frame                           .58
  4       Dbl, 1/4 in., Mtl w/Storm                          .53
  5       Dbl, 1/4 in., TIM w/Storm                          .44
  6       Dbl, 1/4 in., Wood w/Storm                         .35
  7       Dbl, 1/2 in., Metal Frame                          .64
  8       Dbl, 1/2 in., TIM Frame                            .56
  9       Dbl, 1/2 in., Wood Frame                           .49
 10       Dbl, 1/2 in., Metal w/Storm                        .48
     Press <PgDn> to view next menu page or <PgUp> to view previous page

WINDOW No. 1                  U-Value     Area    Cost/ft2    UA    Total Cost
     Construction Type      Btu/ft2-Fh     ft2      $/ft2  Btu/F-hr
curr:                            0.000     0.0      $0.00     0.0      $0.00
prop:                            0.000     0.0      $0.00     0.0      $0.00

SUMMARY FOR WINDOW:                    No. of Entries    Total UA    Total Cost
                              current :             1         0.0       $0.00
                              proposed:             1         0.0       $0.00

   Press <↑> or <↓> to scroll components; <E> to edit data; <ESC> to quit
```

To enter the window information for *current* and *proposed* from our example, enter:

(E) [Check that *current* is flashing.]

(T)

1 (RET)

168 (RET)

(T)

5 (RET)

(C)

2.55 (RET)

(ESC)

You should see:

WATTSUN V3.1: MENU OF WINDOWS

Number	Construction Type	U-Value (Btu/ft2-Fh)
1	Dbl, 1/4 in., Metal Frame	.75
2	Dbl, 1/4 in., TIM Frame	.67
3	Dbl, 1/4 in., Wood Frame	.58
4	Dbl, 1/4 in., Mtl w/Storm	.53
5	Dbl, 1/4 in., TIM w/Storm	.44
6	Dbl, 1/4 in., Wood w/Storm	.35
7	Dbl, 1/2 in., Metal Frame	.64
8	Dbl, 1/2 in., TIM Frame	.56
9	Dbl, 1/2 in., Wood Frame	.49
10	Dbl, 1/2 in., Metal w/Storm	.48

Press <PgDn> to view next menu page or <PgUp> to view previous page

WINDOW No. 1 Construction Type	U-Value Btu/ft2-Fh	Area ft2	Cost/ft2 $/ft2	UA Btu/F-hr	Total Cost
curr: Dbl, 1/4 in., Metal Frame	0.750	168.0	$0.00	126.0	$0.00
prop: Dbl, 1/4 in., TIM w/Storm	0.440	168.0	$2.55	73.9	$428.40

SUMMARY FOR WINDOW:	No. of Entries	Total UA	Total Cost
current :	1	126.0	$0.00
proposed:	1	73.9	$428.40

Press <I> or <i> to scroll component; <E> to edit data; <ESC> to quit

To proceed to the Solar Menu, press:

(ESC)

Notice that you are now in the Effective Solar Glazing Menu. This occurs when the window area in the building component is changed. WATTSUN automatically takes the user to the Solar Menu to change the solar area.

There are additional inputs for solar area that you are asked for after entering window components. You will need to enter the direction and area of the windows in your building. For

this exercise, you should enter the specifications from the example worksheet. You can always get back into the Solar Menu by going to the Main Menu and typing **5**. This will be useful for changing window areas and direction. Remember, the solar area in the Solar Menu *must* always be equal to or less than the window area in the Building Component Menu. You can check this by comparing the total solar area to the total glazing area entered for UA for both *current* and *proposed*. Remember to always change the window and wall area of the Component Menu prior to changing the Solar Menu.

Note: WATTSUN solar inputs assume that all windows are unshaded. This tends to underestimate energy use and energy savings. The no-shading assumption is acceptable for determining Super Good Cents compliance.

From our example worksheet, enter the window areas for each direction in the *current* and *proposed* home by specifying the number corresponding to the direction the windows face and that area, for all directions in both cases.

Remember to use the (HOME) key to switch between cases if differences exist between the *current* and *proposed* cases, although we needn't do this in the example run. After entering all the solar information, you should see:

MATTSUN V3.1: EFFECTIVE SOLAR GLAZING

Calculating effective solar glazing for Portland, OR

NO.	ORIENTATION	CURRENT Area	CURRENT % of Floor	PROPOSED Area	PROPOSED % of Floor
1	South	42.0	3.0%	42.0	3.0%
2	Southeast	0.0	0.0%	0.0	0.0%
3	East	42.0	3.0%	42.0	3.0%
4	Northeast	0.0	0.0%	0.0	0.0%
5	North	42.0	3.0%	42.0	3.0%
6	Northwest	0.0	0.0%	0.0	0.0%
7	West	42.0	3.0%	42.0	3.0%
8	Southwest	0.0	0.0%	0.0	0.0%
TOTAL SOLAR AREA:		168.00	12.0%	168.00	12.0%
TOTAL GLAZING AREA ENTERED FOR UA		168.00		168.00	

Press number of menu choice or <ESC> to quit CURRENT

1-SOUTH 2-SOUTHEAST 3-EAST 4-NORTHEAST 5-NORTH 6-NORTHWEST 7-WEST 8-SOUTHWEST

To enter the next building component, enter:

(ESC)

The program will return to the Building Component Menu. Now let's enter doors. Enter:

6 (RET)

You should see:

MATTSUN V3.1: MENU OF DOORS

Number	Construction Type	U-Value (Btu/ft2-Fh)
1	1.75in Flsh Hlw Core Wood	.46
2	1.75in F.H.C.Wood w/Strm	.32
3	1.75in Flsh Sld Core Wood	.33
4	1.75in F.S.C Wood w/Strm	.28
5	1.75in-7/16in Panel Wood	.54
6	1.75in-7/16in Pnl Wd+Strm	.36
7	1.75in-1-1/8in Panl Wood	.39
8	1.75in-1-1/8in Pnl Wd+Stm	.28
9	1.75in Foam w/Therm. Brk	.19
10	1.75in Foam w/o Therm.Brk	.4

Press <PgDn> to view next menu page or <PgUp> to view previous page

DOOR No. 1 Construction Type	U-Value Btu/ft2-Fh	Area ft2	Cost/ft2 $/ft2	UA Btu/F-hr	Total Cost
curr:	0.000	0.0	$0.00	0.0	$0.00
prop:	0.000	0.0	$0.00	0.0	$0.00

SUMMARY FOR DOOR:	No. of Entries	Total UA	CURRENT Total Cost
current :	1	0.0	$0.00
proposed:	1	0.0	$0.00

Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit

To enter the door information for *current* and *proposed* from our example, enter:

(E) [Check that *current* is flashing.]

(T)

3 (RET)

42 (RET)

(T)

9 (RET)

(C)

3.50 (RET)

(ESC)

After reviewing the door data entered, enter the next building component by pressing:

(ESC)

The program will return to the Building Component Menu. Now let's enter ceilings. Enter:

8 (RET)

You should see:

```
                    WATTSUN V3.1: MENU OF CEILINGS

Number     Construction Type                              U-Value  (Btu/ft2-Fh)
 1       R-30 2x6 Joist, Std                                 .042
 2       R-30 2x6 Joist, Adv                                 .035
 3       R-30 2x4 Truss, Std                                 .041
 4       R-30 2x4 Truss, Adv                                 .034
 5       R-38 Joist/Truss, Std                               .036
 6       R-38 Joist/Truss, Adv                               .027
 7       R-49 Joist/Truss, Std                               .032
 8       R-49 2x6 Joist, Adv                                 .022
 9       R-49 2x4 Truss, Adv                                 .021
 10      R-60 Joist/Truss, Std                               .029
     Press <PgDn> to view next menu page or <PgUp> to view previous page

CEILING No. 1                 U-Value     Area    Cost/ft2    UA    Total Cost
     Construction Type        Btu/ft2-Fh  ft2     $/ft2    Btu/F-hr
curr:                           0.000      0.0     $0.00      0.0     $0.00
prop:                           0.000      0.0     $0.00      0.0     $0.00

SUMMARY FOR CEILING:                    No. of Entries    Total UA    Total Cost
                              current :         1              43.1       $0.00
                              proposed:         1              37.8     $126.00

    Press <I> or <i> to scroll component; <E> to edit data; <ESC> to quit
```

Some components, such as ceilings, walls, and windows, have more than 10 choices. Let's view more choices. Press:

(PG DN)

You should see:

MATTSUN V3.1: MENU OF CEILINGS

Number	Construction Type	U-Value (Btu/ft2-Fh)
11	R-60 2x6 Joist, Adv	.018
12	R-60 2x4 Truss, Adv	.017
13	R-11 Vaulted	.072
14	R-19 Vaulted	.049
15	R-30 Vaulted	.035
16	R-38 Vaulted	.028
17	OTHER	0

Press <PgDn> to view next menu page or <PgUp> to view previous page

CEILING No. 1 Construction Type	U-Value Btu/ft2-Fh	Area ft2	Cost/ft2 $/ft2	UA Btu/F-hr	Total Cost
curr:	0.000	0.0	$0.00	0.0	$0.00
prop:	0.000	0.0	$0.00	0.0	$0.00

SUMMARY FOR CEILING:	No. of Entries	Total UA	Total Cost
current :	1	0.0	$0.00
proposed:	1	0.0	$0.00

Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit

Press:

(PG UP)

You should see:

WATTSUN V3.1: MENU OF CEILINGS

Number	Construction Type	U-Value (Btu/ft2-Fh)
1	R-30 2x6 Joist, Std	.042
2	R-30 2x6 Joist, Adv	.035
3	R-30 2x4 Truss, Std	.041
4	R-30 2x4 Truss, Adv	.034
5	R-38 Joist/Truss, Std	.036
6	R-38 Joist/Truss, Adv	.027
7	R-49 Joist/Truss, Std	.032
8	R-49 2x6 Joist, Adv	.022
9	R-49 2x4 Truss, Adv	.021
10	R-60 Joist/Truss, Std	.029

Press <PgDn> to view next menu page or <PgUp> to view previous page

CEILING No. 1 Construction Type	U-Value Btu/ft2-Fh	Area ft2	Cost/ft2 $/ft2	UA Btu/F-hr	Total Cost
curr:	0.000	0.0	$0.00	0.0	$0.00
prop:	0.000	0.0	$0.00	0.0	$0.00

SUMMARY FOR CEILING:	No. of Entries	Total UA	Total Cost
current :	1	0.0	$0.00
proposed:	1	0.0	$0.00

Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit

From our example worksheet we have 1050 ft² of R-30 standard framing and 409 ft² of R-30 vaulted ceiling for the *current* home. The *proposed* home has 1050 ft² of R-38 standard truss framing and costs $0.12/ft² more than the *current* home R-30 standard framing. The proposed home has the same 409 ft²of R-30 vaulted ceiling.

Let's first enter the R-30 standard framing type for the *current* home. To do this you must enter the number corresponding to the insulation type that you want. Press:

(E)

(T)

3 (RET)

1050 (RET)

Now let's enter *proposed*. Press:

(T)

5 (RET)

(C)

.12 (RET)

You should see:

WATTSUN V3.1: MENU OF CEILINGS

Number	Construction Type	U-Value (Btu/ft2-Fh)
1	R-30 2x6 Joist, Std	.042
2	R-30 2x6 Joist, Adv	.035
3	R-30 2x4 Truss, Std	.041
4	R-30 2x4 Truss, Adv	.034
5	R-38 Joist/Truss, Std	.036
6	R-38 Joist/Truss, Adv	.027
7	R-49 Joist/Truss, Std	.032
8	R-49 2x6 Joist, Adv	.022
9	R-49 2x4 Truss, Adv	.021
10	R-60 Joist/Truss, Std	.029

Press <PgDn> to view next menu page or <PgUp> to view previous page

CEILING No. 1 Construction Type	U-Value Btu/ft2-Fh	Area ft2	Cost/ft2 $/ft2	UA Btu/F-hr	Total Cost
curr: R-30 2x4 Truss, Std	0.041	1050.0	$0.00	43.1	$0.00
prop: R-38 Joist/Truss, Std	0.036	1050.0	$0.12	37.8	$126.00

Press <T> for const. type; <A> for area; <C>ost or <#> to delete PROPOSED

Press <↑><↓> to scroll comp.; <HOME> to change case; <ESC> to quit

We are now ready to enter our number 2 ceiling type (vaulted). Pressing (↓) allows you to enter another type of a component. Pressing (↑) allows you to view the previous component type. You can always tell how many types of a component have been entered for the *current* and/or *proposed* home by pressing (ESC) for the component summary. Press:

(ESC) (↓)

You should see:

WATTSUN V3.1: MENU OF CEILINGS

Number	Construction Type	U-Value (Btu/ft2-Fh)
1	R-30 2x6 Joist, Std	.042
2	R-30 2x6 Joist, Adv	.035
3	R-30 2x4 Truss, Std	.041
4	R-30 2x4 Truss, Adv	.034
5	R-38 Joist/Truss, Std	.036
6	R-38 Joist/Truss, Adv	.027
7	R-49 Joist/Truss, Std	.032
8	R-49 2x6 Joist, Adv	.022
9	R-49 2x4 Truss, Adv	.021
10	R-60 Joist/Truss, Std	.029

Press <PgDn> to view next menu page or <PgUp> to view previous page

CEILING No. 2 Construction Type	U-Value Btu/ft2-Fh	Area ft2	Cost/ft2 $/ft2	UA Btu/F-hr	Total Cost
curr:	0.000	0.0	$0.00	0.0	$0.00
prop:	0.000	0.0	$0.00	0.0	$0.00

SUMMARY FOR CEILING:	No. of Entries	Total UA	Total Cost
current :	1	43.1	$0.00
proposed:	1	37.8	$126.00

Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit

Press:

(PG DN)

(E)

(HOME)

(T)

15 (RET)

409 (RET)

You should see:

```
                    NATTSUN V3.1: MENU OF CEILINGS

Number     Construction Type                          U-Value  (Btu/ft2-Fh)
 11        R-60 2x6 Joist, Adv                           .018
 12        R-60 2x4 Truss, Adv                           .017
 13        R-11 Vaulted                                  .072
 14        R-19 Vaulted                                  .049
 15        R-30 Vaulted                                  .035
 16        R-38 Vaulted                                  .028
 17        OTHER                                         0


     Press <PgDn> to view next menu page or <PgUp> to view previous page

CEILING No. 2                  U-Value    Area    Cost/ft2    UA    Total Cost
     Construction Type       Btu/ft2-Fh    ft2      $/ft2  Btu/F-hr
curr: R-30 Vaulted               0.035    409.0      $0.00    14.3      $0.00
prop: R-30 Vaulted               0.035    409.0      $0.00    14.3      $0.00
 Press <T> for const. type; <A> for area; <C>ost or <#> to delete       PROPOSED


   Press <↑><↓> to scroll comp.; <HOME> to change case; <ESC> to quit
```

Notice that the *current* and *proposed* have both been entered. We do not need to enter any costs for the *proposed* home, since both cases are the same. You could continue adding more ceiling types using the (↓) commands. For this example, however, we have finished entering ceiling types. Always check the component summary to see if all the types of ceilings have been entered. Press:

(ESC)

You should see:

NATTSUN V3.1: MENU OF CEILINGS

Number	Construction Type	U-Value (Btu/ft2-Fh)
11	R-60 2x6 Joist, Adv	.018
12	R-60 2x4 Truss, Adv	.017
13	R-11 Vaulted	.072
14	R-19 Vaulted	.049
15	R-30 Vaulted	.035
16	R-38 Vaulted	.028
17	OTHER	0

Press <PgDn> to view next menu page or <PgUp> to view previous page

CEILING No. 2 Construction Type	U-Value Btu/ft2-Fh	Area ft2	Cost/ft2 $/ft2	UA Btu/F-hr	Total Cost
curr: R-30 Vaulted	0.035	409.0	$0.00	14.3	$0.00
prop: R-30 Vaulted	0.035	409.0	$0.00	14.3	$0.00

SUMMARY FOR CEILING:	No. of Entries	Total UA	Total Cost
current :	2	57.4	$0.00
proposed:	2	52.1	$126.00

Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit

Let's go back to the Building Component Menu to finish adding the other building components. Press:

(ESC)

Now, enter the last two building components (air leakage control and thermal mass) without directions. Remember, (E) to edit, (T) for construction type, (C) for costs, and (ESC) to change menus.

A Note About Thermal Mass: All residential buildings fall into one of the first three mass types. If additional mass is used, show it as mass #2.

When you have completed those entries, you should see:

MATTSUN V3.1: BUILDING COMPONENT MENU

COMPONENT	CURRENT UAc	PROPOSED UAp	(CURRENT-PROPOSED) UAc-UAp	INC. COST	COST/UA
1 BELOW GRADE WALL/FLOOR	0.0	0.0	0.0	$0.00	
2 SLAB ON GRADE	0.0	0.0	0.0	$0.00	
3 CRAWL SPACE FLOOR	79.8	57.4	22.4	$168.00	7.5$/Btu
4 ABOVE GRADE WALL	102.0	70.9	31.1	$298.56	9.6$/Btu
5 WINDOW	126.0	73.9	52.1	$428.40	8.2$/Btu
6 DOOR	13.9	8.0	5.9	$147.00	25.0$/Btu
7 SKYLIGHT	0.0	0.0	0.0	$0.00	
8 CEILING	57.4	52.1	5.3	$126.00	24.0$/Btu
9 AIR LEAKAGE CONTROL	134.3	56.0	78.3	$1700.00	21.7$/Btu
0 THERMAL MASS	4200.0	4200.0		$0.00	
TOTALS:	513.3	318.3	195.1	$2867.96	14.7$/Btu

QUALIFICATION CRITERIA	Current	Proposed
Thermal Performance (Btu/ft2 floor)	0.361	0.225
Energy Budget (kWh/ft2 of floor)	6.06	2.29

Press number of menu choice or <ESC> to quit

1-BASMNT 2-SLAB 3-CRWLSPC 4-WALL 5-WNDOW 6-DOOR 7-SKYLIT 8-CEILNG 9-INF 0-MASS

When you are certain that all the building components have been entered correctly, press:

(ESC)

You should see:

WATTSUN V3.1: MENU OF CEILINGS

Number	Construction Type	U-Value (Btu/ft2-Fh)
11	R-60 2x6 Joist, Adv	.018
12	R-60 2x4 Truss, Adv	.017
13	R-11 Vaulted	.072
14	R-19 Vaulted	.049
15	R-30 Vaulted	.035
16	R-38 Vaulted	.028
17	OTHER	0

Press <PgDn> to view next menu page or <PgUp> to view previous page

CEILING No. 2 Construction Type		U-Value Btu/ft2-Fh	Area ft2	Cost/ft2 $/ft2	UA Btu/F-hr	Total Cost
curr:	R-30 Vaulted	0.035	409.0	$0.00	14.3	$0.00
prop:	R-30 Vaulted	0.035	409.0	$0.00	14.3	$0.00

SUMMARY FOR CEILING:	No. of Entries	Total UA	Total Cost
current :	2	57.4	$0.00
proposed:	2	52.1	$126.00

Press <↑> or <↓> to scroll component; <E> to edit data; <ESC> to quit

Let's go back to the Building Component Menu to finish adding the other building components. Press:

(ESC)

Now, enter the last two building components (air leakage control and thermal mass) without directions. Remember, (E) to edit, (T) for construction type, (C) for costs, and (ESC) to change menus.

A Note About Thermal Mass: All residential buildings fall into one of the first three mass types. If additional mass is used, show it as mass #2.

When you have completed those entries, you should see:

NATTSUN V3.1: BUILDING COMPONENT MENU

	CURRENT	PROPOSED	(CURRENT-PROPOSED)		
COMPONENT	UAc	UAp	UAc-UAp	INC. COST	COST/UA
1 BELOW GRADE WALL/FLOOR	0.0	0.0	0.0	$0.00	
2 SLAB ON GRADE	0.0	0.0	0.0	$0.00	
3 CRAWL SPACE FLOOR	79.8	57.4	22.4	$168.00	7.5$/Btu
4 ABOVE GRADE WALL	102.0	70.9	31.1	$298.56	9.6$/Btu
5 WINDOW	126.0	73.9	52.1	$428.40	8.2$/Btu
6 DOOR	13.9	8.0	5.9	$147.00	25.0$/Btu
7 SKYLIGHT	0.0	0.0	0.0	$0.00	
8 CEILING	57.4	52.1	5.3	$126.00	24.0$/Btu
9 AIR LEAKAGE CONTROL	134.3	56.0	78.3	$1700.00	21.7$/Btu
0 THERMAL MASS	4200.0	4200.0		$0.00	
TOTALS:	513.3	318.3	195.1	$2867.96	14.7$/Btu

QUALIFICATION CRITERIA	Current	Proposed
Thermal Performance (Btu/ft2 floor)	0.361	0.225
Energy Budget (kWh/ft2 of floor)	6.06	2.29

Press number of menu choice or <ESC> to quit

1-BASMNT 2-SLAB 3-CRWLSPC 4-WALL 5-WNDOW 6-DOOR 7-SKYLIT 8-CEILNG 9-INF 0-MASS

When you are certain that all the building components have been entered correctly, press:

(ESC)

Heating Systems

WATTSUN 3.1 will calculate the size of the heating equipment required to maintain a user specified indoor thermostat setpoint at the ASHRAE winter design temperature for the location selected. The user can adjust the winter design temperature, if required, for any other location. The program calculates the size of heating plant required to provide 125 percent of the home's heating requirements. You should see:

WATTSUN V3.1: HEATING SYSTEM SIZING MENU

HEATING SYSTEM TYPE	Current Central Forced Air	Proposed Baseboard heaters
HEATING SYSTEM COST	$1000.00	$500.00
BUILDING HEAT LOSS		
Building Envelope Heat Loss (Btu/F-hr)	513.3	318.3
Heating System Duct Loss (Btu/F-hr)	10.0	0.0
Total Heat Loss:	523.3	318.3
DESIGN HEAT LOAD in Btu/hr (kW)	24,596.6 (7.2kW)	14,959.2 (4.4kW)
SYSTEM SIZE (125%) in kBtu/hr (kW)	31.0 (9.5kW)	19.0 (5.5kW)
TOTAL ANNUAL AUXILIARY SPACE HEAT (kWh/yr)	10101	3685

Thermostat Set Point: 70.0 deg F
ASHRAE 97.5% Winter Design Temp: 23.0 deg F
Design Temperature Difference: 47.0 deg F

Press number of menu choice or <ESC> to quit

1-TYPE 2-COST 3-DUCT LOSSES 4-THERMOSTAT 5-WINTER DESIGN TEMPERATURE

Notice default values are already entered with *current* as a furnace. In our example we have baseboard heating in both *current* and *proposed* homes. To review the various selections for heating systems, enter:

1 (RET)

To select baseboards, you will need to enter the heating system type for *current*. Enter:

1 (RET)

You should see:

WATTSUN V3.1: HEATING SYSTEM SIZING MENU		
HEATING SYSTEM TYPE	Current Baseboard heaters	Proposed Baseboard heaters
HEATING SYSTEM COST	$1000.00	$500.00
BUILDING HEAT LOSS		
Building Envelope Heat Loss (Btu/F-hr)	513.3	318.3
Heating System Duct Loss (Btu/F-hr)	0.0	0.0
Total Heat Loss:	513.3	318.3
DESIGN HEAT LOAD in Btu/hr (kW)	24,126.6 (7.1kW)	14,959.2 (4.4kW)
SYSTEM SIZE (125%) in kBtu/hr (kW)	30.5 (9.0kW)	19.0 (5.5kW)
TOTAL ANNUAL AUXILIARY SPACE HEAT (kWh/yr)	9760	3685
Thermostat Set Point:	70.0 deg F	
ASHRAE 97.5% Winter Design Temp:	23.0 deg F	
Design Temperature Difference:	47.0 deg F	
Press number of menu choice or <ESC> to quit		
1-TYPE 2-COST 3-DUCT LOSSES 4-THERMOSTAT 5-WINTER DESIGN TEMPERATURE		

Let's enter costs of our baseboard examples. Enter:

2 (RET)

Note: When using heat pumps or forced air furnaces, you must specify the heat loss associated with ducts in unheated spaces. To do this you will need to know the R-value, duct sizes, and lengths in unheated spaces. Refer to Tables A and B in the Input Worksheet. Directions for the use of Tables A and B are outlined below. In addition, if you are using a heat pump, refer to Section VI.

Duct Heat Loss

To calculate duct heat loss:

- Put the lineal feet of each size of duct in the "lineal feet" column of Table B of the Input Worksheet.
- Then find the duct size or dimension in the "duct size" column in Table A (Input Worksheet).
- Move to the right beneath the appropriate R-value for that duct size.
- The value appears in bold print.
- In Table B, multiply the lineal feet times the value in Table A for each duct run.
- In Table B, sum the product lines 1, 2, and 3.
- This sum is the final number to be used for the heating system duct loss.

You will be asked to input costs for the *current* and *proposed* heating systems. In most cases you can assume these costs to be slightly lower ($800 vs. $1,000) for the *proposed* case since the home is generally more energy efficient. This may not be the case for passive solar homes where large glass areas exist. The heating system sizing is a "worst case" calculation, i.e., no sunshine, and does not account for solar heating gains. Since the current baseboard cost is the same as our example, we need only to enter the *proposed*. For our *proposed* example, press:

(HOME)

800 (RET)

You should see:

NATTSUN V3.1: HEATING SYSTEM SIZING MENU		
HEATING SYSTEM TYPE	Current Baseboard heaters	Proposed Baseboard heaters
HEATING SYSTEM COST	$1000.00	$800.00
BUILDING HEAT LOSS		
Building Envelope Heat Loss (Btu/F-hr)	513.3	318.3
Heating System Duct Loss (Btu/F-hr)	0.0	0.0
Total Heat Loss:	513.3	318.3
DESIGN HEAT LOAD in Btu/hr (kW)	24,126.6 (7.1kW)	14,959.2 (4.4kW)
SYSTEM SIZE (125%) in kBtu/hr (kW)	30.5 (9.0kW)	19.0 (5.5kW)
TOTAL ANNUAL AUXILIARY SPACE HEAT (kWh/yr)	9760	3685
Thermostat Set Point:	70.0 deg F	
ASHRAE 97.5% Winter Design Temp:	23.0 deg F	
Design Temperature Difference:	47.0 deg F	
Press number of menu choice or <ESC> to quit		
1-TYPE 2-COST 3-DUCT LOSSES 4-THERMOSTAT 5-WINTER DESIGN TEMPERATURE		

You can specify indoor thermostat and outdoor design temperatures by selecting the appropriate menu choice. Since our example requires no change, we have completed the heating system inputs.

Note: The indoor T-STAT setting will affect the economics and the heat system size but *not* the energy budget, which is based on the 65°F indoor temperature assumption and cannot be changed by the user.

To proceed to the Economics, press:

(ESC)

Economics

To run economics, as mentioned earlier, you will need to specify the incremental cost of the proposed home's individual components *or* specify the total (marked-up) costs as "other" in the Economic Menu.

We should have already entered the incremental cost of our example when we were in the Building Component Menu. Let's select the Economics Menu now. You should see:

WATTSUN V3.1: ECONOMICS MENU

		Current	Proposed
BASE PRICE:		$75,000.00	$75,000.00
INCREMENTAL COSTS:	Envelope Improvements	$0.00	$2,867.96
	Heating System Equipment	$1,000.00	$800.00
	Builder Mark-up	$200.00	$733.59
	Other	$0.00	$0.00
	TOTAL INCREMENTAL COST:	$1,200.00	$4,401.55
TOTAL PRICE (BASE+INCREMENTAL):		$76,200.00	$79,401.56
MONTHLY PAYMENT:	Principal+Interest	$705.42	$735.06
	Property Taxes	$127.00	$132.34
	Insurance	$63.50	$66.17
	Income Tax Deduction	-$230.81	-$240.50
	Energy	$40.67	$15.35
	TOTAL MONTHLY PAYMENT:	$705.78	$708.42
30 YEAR LIFE CYCLE COST:		$89,042.06	$88,676.10

Press number of menu choice or <ESC> to quit

1-BASE 2-OTHER 3-MARKUP 4-RATE 5-TERM 6-%DOWN 7-INC.TAX 8-RE.TAX 9-INS. 0-$/KWH

From our example worksheet, enter the economics assumptions 1-10. To enter the base price of the *current* and *proposed* home (excluding heating equipment and incremental costs), enter:

1 (RET)

77000 (RET)

1 (RET)

(HOME)

77000 (RET)

You can check the other economic assumptions and compare them with our worksheet by pressing the number corresponding to the assumption. For example, enter:

4 (RET)

You should see:

MATTSUN V3.1: ECONOMICS MENU

		Current	Proposed
BASE PRICE:		$77,000.00	$77,000.00
INCREMENTAL COSTS:	Envelope Improvements	$0.00	$2,867.96
	Heating System Equipment	$1,000.00	$800.00
	Builder Mark-up	$200.00	$733.59
	Other	$0.00	$0.00
	TOTAL INCREMENTAL COST:	$1,200.00	$4,401.55
TOTAL PRICE (BASE+INCREMENTAL):		$78,200.00	$81,401.56
MONTHLY PAYMENT:	Principal+Interest	$723.94	$753.58
	Property Taxes	$130.33	$135.67
	Insurance	$65.17	$67.83
	Income Tax Deduction	-$236.86	-$246.56
	Energy	$40.67	$15.35
	TOTAL MONTHLY PAYMENT:	$723.24	$725.87
30 YEAR LIFE CYCLE COST:		$91,216.88	$90,850.91

Enter new value or press <ESC> to quit

Current Mortgage rate (%) 12 . New value:

1-BASE 2-OTHER 3-MARKUP 4-RATE 5-TERM 6-%DOWN 7-INC.TAX 8-RE.TAX 9-INS. 0-$/KWH

Since this agrees with our worksheet, continue by pressing:

(ESC)

Check *all* the *economic assumptions*. When finished, the Economics Menu should look like this:

MATTSUN V3.1: ECONOMICS MENU

		Current	Proposed
BASE PRICE:		$77,000.00	$77,000.00
INCREMENTAL COSTS:	Envelope Improvements	$0.00	$2,867.96
	Heating System Equipment	$1,000.00	$800.00
	Builder Mark-up	$200.00	$733.59
	Other	$0.00	$0.00
	TOTAL INCREMENTAL COST:	$1,200.00	$4,401.55
TOTAL PRICE (BASE+INCREMENTAL):		$78,200.00	$81,401.56
MONTHLY PAYMENT:	Principal+Interest	$723.94	$753.58
	Property Taxes	$65.17	$67.83
	Insurance	$65.17	$67.83
	Income Tax Deduction	-$223.83	-$232.99
	Energy	$40.67	$15.35
	TOTAL MONTHLY PAYMENT:	$671.11	$671.61
30 YEAR LIFE CYCLE COST:		$85,319.35	$84,711.95

Press number of menu choice or <ESC> to quit

1-BASE 2-OTHER 3-MARKUP 4-RATE 5-TERM 6-%DOWN 7-INC.TAX 8-RE.TAX 9-INS. 0-$/KWH

Now that the menus have been completed, return to the Main Menu by pressing:

(ESC)

You should see:

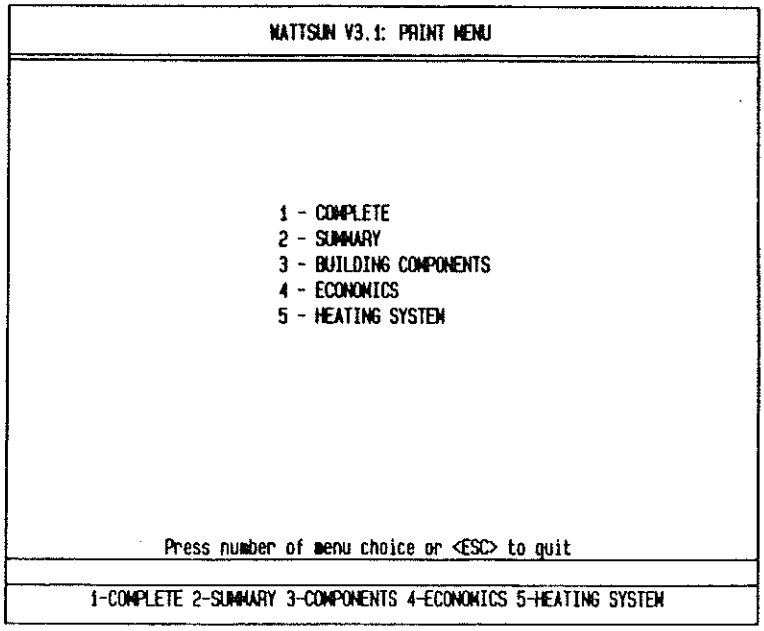
MATTSUN V3.1 MAIN MENU		
House ID : EXAMPLE RANCH House Site: 5001 MUD BAY RD, OLYMPIA, WA Builder : TEN PENNY CONSTRUCTION Homeowner : JOE HOMEOWNER	Utility : LOCAL UTILITY Analyst : ENERGY JOE Location : Portland, OR Floor Area : 1,400 ft2	
QUALIFICATION CRITERIA	Current	Proposed
Thermal Performance (Btu/ft2 of floor) Energy Budget (kWh/ft2 of floor)	0.361 6.06	0.225 2.29
HEATING SYSTEM		
Heating System Size in kBtu/hr (kW) Total Annual Auxiliary Space Heat (kWh)	30.5(9.0kW) 9,760	19.0(5.5kW) 3,685
ECONOMICS		
First Year Monthly PITI+Energy ($/mo) 30 Year Life Cycle Cost ($)	$671.11 $85,319.35	$671.61 $84,711.95
Press number of menu choice or <ESC> to quit		
1-I.D. 2-COMPONENT 3-AREA 4-LOCATION 5-SOLAR 6-ECON 7-HEAT SYS. 8-PRINT 9-FILE		

Printing WATTSUN

While in the Main Menu, you can print your program by entering:

8 (RET)

You should see:


WATTSUN V3.1: PRINT MENU
1 - COMPLETE
2 - SUMMARY
3 - BUILDING COMPONENTS
4 - ECONOMICS
5 - HEATING SYSTEM
Press number of menu choice or <ESC> to quit
1-COMPLETE 2-SUMMARY 3-COMPONENTS 4-ECONOMICS 5-HEATING SYSTEM

You can choose either a partial printout or a complete printout by specifying the number corresponding to the printout desired. Enter:

1 (RET)

Get your printer ready, and press:

(RET)

It is good practice to make a printed copy of all new files before you exit the WATTSUN program.

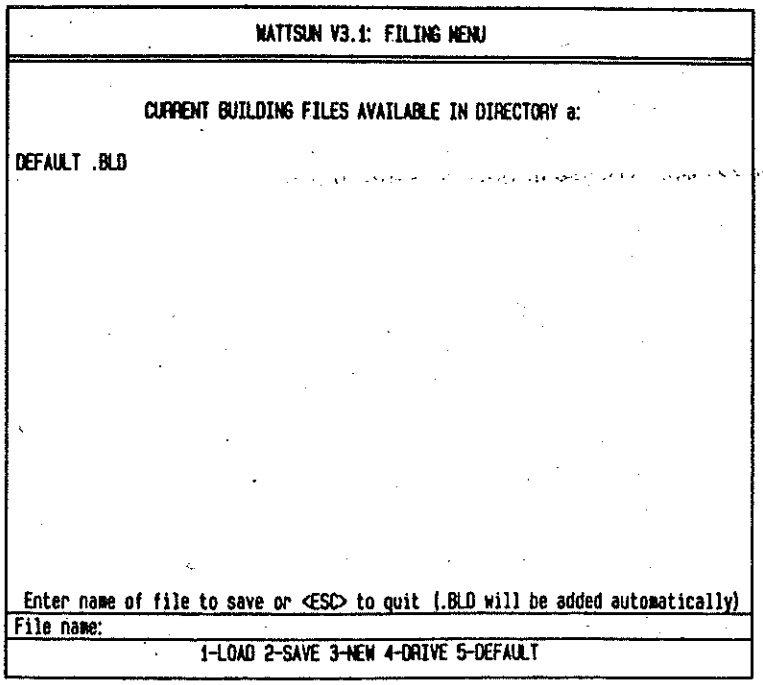
Storing Our Example

You can access the Files Menu from the Main Menu by typing 9- while in the Main Menu. Let's save our example file to the Working Program Disk in drive A. Enter:

9 (RET)

2 (RET)

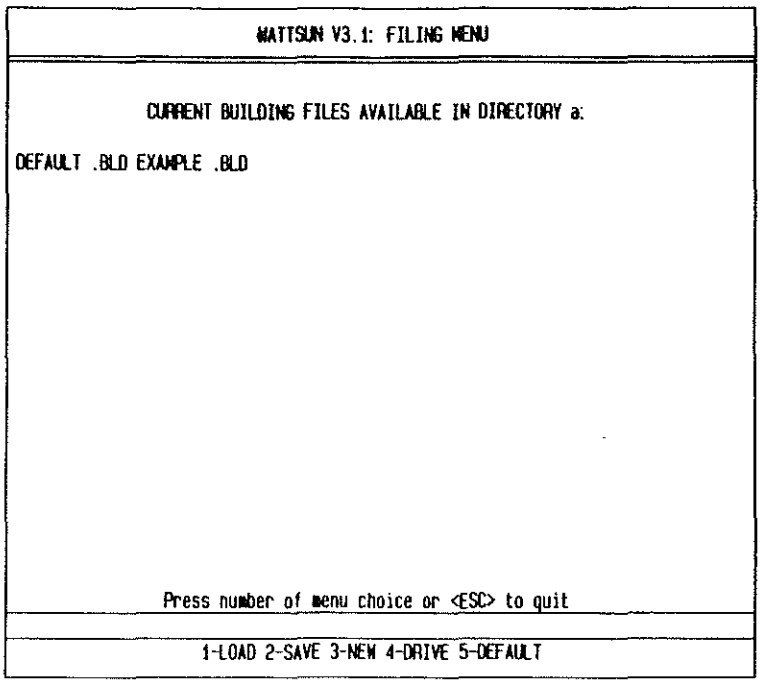
You should see:


MATTSUN V3.1: FILING MENU
CURRENT BUILDING FILES AVAILABLE IN DIRECTORY a:
DEFAULT .BLD
Enter name of file to save or <ESC> to quit (.BLD will be added automatically)
File name:
1-LOAD 2-SAVE 3-NEW 4-DRIVE 5-DEFAULT

Using 8 characters or less, give your work sample a name by entering:

EXAMPLE (RET)

You should see:


WATTSUN V3.1: FILING MENU
CURRENT BUILDING FILES AVAILABLE IN DIRECTORY a:
DEFAULT .BLD EXAMPLE .BLD
Press number of menu choice or <ESC> to quit
1-LOAD 2-SAVE 3-NEW 4-DRIVE 5-DEFAULT

Your building file is now saved on the WATTSUN Working Disk in drive A.

Note: You should be able to save 25-50 WATTSUN runs on the Working Program Disk, or you can store WATTSUN runs on separate Working Data Disks in drive B.

To store the WATTSUN building file on the Working Data Disk in drive B, enter:

4 (RET)

You are asked for directory A, B, C. Enter:

B (RET)

Then save the building file by entering:

2 (RET)

Enter:

EXAMPLE (RET)

Your building file is now saved on the Working Disk in drive B.

To exit WATTSUN, return to the Main Menu by pressing:

(ESC)

From the Main Menu, press:

(ESC)

You'll hear a tone, then enter:

(E)

Creating Back-Up Data Files

It is important to always make back-up copies of information you want to keep. The WATTSUN program allows you to store different sets of building data on the Working Data Disk. To back-up the Working Data Disk after an input session, do the following:

1. Place your DOS disk in drive A and enter the command below, then press return:

   DISKCOPY A: B:

2. At the prompt, *"Press any key when ready"*, place the Working Data Disk in drive A and the Back-Up Data Disk in drive B, then press any key. This will copy the contents of the working copy to the back-up copy. Note that the former contents of the back-up disk will be overwritten. When asked if

another disk is to be copied, enter N for no, then press return. At the A> prompt, remove data disks and put them in a safe place.

Summary of File Commands

Command	Explanation of Command
LOAD	Loads the file you specify from the current directory (disk), into the WATTSUN program.
SAVE	Saves a file that you have created and named to the current directory. (Directories: A = Drive A; B = Drive B; C = Hard Disk).
NEW	Creates a new file which blanks out any default information presently in the WATTSUN program and leads you through a preprogrammed data entry sequence.
DRIVE	Allows you to specify or change which directory WATTSUN loads building files from, i.e., A, B, or C.
DEFAULT	The operator can edit default files, although it is not recommended.

Editing Existing Files

All commands for editing files are the same as shown in the "new file" example. When editing a building file, the user moves into menus from the Main Menu by selecting the appropriate number for the desired menu. To exit a menu, the user presses the (ESC) key and the program will return to the Main Menu.

Time Saving Hint: When starting the program, the message line asks, "Do you want help with the menus (y/n)?" Type N. This will eliminate the need to press (RET) when selecting a menu, and eliminates the need to press (E) to edit. All other commands will be the same.

Cost Data

Overview of Cost Accounting

The following cost information was compiled by the Washington State Energy Office. Cost data were supplied from over 300 general contractors who constructed 400 residences in Washington, Oregon, Idaho, and Montana. These residences were built to meet or exceed the Model Conservation Standards (MCS) and the specifications of the Bonneville Power Administration's Residential Standards Demonstration Program.

The median (average) costs and sample size are indicated for each component's incremental cost:

R-11 walls 2x4 studs 16" o.c. to R-19 walls 2x6 studs 24" o.c.

Median costs difference: $0.26/ft^2.

Sample size: 48 residences.

Minimum-maximum range: 0-$1.71.

You can use these tables to determine some of the cost information required by the WATTSUN economic analysis worksheets and design optimizations. This cost data can also serve as useful feedback to builders, utility persons, homeowners, architects, and engineers interested in evaluating energy conservation options in new residences.

Great care should be taken when using this data since significant variations occur in costs from builder to builder and design to design. Because these homes were "demonstration" homes, the circumstances surrounding their construction are probably different than most. Maximum and minimum costs are included to indicate the extent of these variations.

A short narrative on some components was included to provide a better understanding of the origin of these costs and what they include. The most accurate cost will ultimately come from the

specific builder and his sub-contractors. These cost data are supplied to complement that which the builder may already have. All efforts should be made by the WATTSUN user to validate or obtain cost data from his or her specific marketplace. The user is encouraged to check with local insulation contractors, HVAC contractors, equipment suppliers, and other contractors involved with residential construction to validate costs.

Cost Data Tables

Normalized Incremental Building Costs — Group Analysis

In this section, we present a detailed analysis of incremental building component costs normalized (standardized) by *component area* for selected groups of components. Those cases not included in a numbered group are analyzed separately as part of the group "all other cases of increments." The building components are ceiling, floor, walls, basement walls, windows, air infiltration barriers, door, and air-to-air heat exchangers. This detailed analysis will be of special value for home builders who are interested in the cost of going from one particular level of ceiling insulation, for example, to another level of ceiling insulation. Moreover, this chapter contains the "cleanest" data because unusual cases are not included in the analysis.

Table 1
Incremental Costs Per Square Foot of Basement Wall
By Types of Increments

Group No.	Current Practice	MCS	Mean ($/ft²)	Standard Deviation ($/ft²)	Median ($/ft²)	Min.-Max. ($/ft²)	Sample Size
1	R- 0 Type 15	R-11 Type 15	0.46	0.22	0.36	0.22-0.88	12
2	R- 0 Type 15	R-19 Type 15	0.80	0.30	1.01	0.40-1.19	9
3	R- 0 Type 22	R-10 Type 14	1.15	0.77	0.99	0.47-1.98	3
4	R- 5 Type 14	R-10 Type 14	0.54	0.22	0.60	0.23-0.75	4
5	R-11 Type 13	R-19 Type 13	0.42	0.49	0.22	-0.09-1.49	16
All other cases of increments			0.61	0.75	0.59	-1.21-3.25	62

Basement Wall Type Code

13 All weather wood foundation.
14 Cement, foam outside.
15 Cement, batt inside.
21 2x4, 16" o.c. standard framing.
22 No insulation on foundation.

For current practice, Type 15 includes Type 21 and 22; and Type 13 includes Type 15.

For MCS, Type 15 includes Type 21; Type 13 includes Type 15; R-11 includes R-13; and R-19 includes R-22.

Table 2
Incremental Costs Per Square Foot of Floor
By Types of Increments

Group No.	Current Practice	MCS	Mean ($/ft²)	Standard Deviation ($/ft²)	Median ($/ft²)	Min.-Max. ($/ft²)	Sample Size
1	R-11 Type 1	R-19 Type 1	0.13	0.08	0.11	0.02- 0.54	61
2	R-11 Type 1	R-30 Type 1	0.40	0.42	0.30	0.11- 3.03	48
3	R-11 Type 1	R-38 Type 1	0.37	0.11	0.40	0.11- 0.47	9
4	R-19 Type 1	R-30 Type 1	0.32	0.17	0.27	0.14- 0.67	12
5	R- 0 Type 2	R- 5 Type 2	0.60	0.41	0.43	0.07- 1.14	12
6	R- 0 Type 2	R-10 Type 2	1.02	0.85	0.76	0.04- 2.76	9
7	R- 0 Type 2	R-15 Type 2	1.52	0.57	1.22	1.17- 2.18	3
8	R- 0 Type 3	R-10 Type 3	1.49	0.77	1.36	0.46- 3.12	16
9	R- 5 Type 3	R-10 Type 3	0.80	0.29	0.72	0.36- 1.42	12
10	R- 5 Type 3	R-15 Type 3	8.97	15.53	2.91	0.12-36.50	5
All other cases of increments			0.71	1.83	0.21	-0.64-11.80	67

Floor Type Code

1 Crawl space (Insulation under floor or overhangs).
2 Slab below-grade.
3 Slab on grade.
5 Slab/foam insulation.

For current practice, Type 3 includes Type 5.

For MCS, Type 2 includes Type 5; Type 3 includes Type 5; R-5 includes R-6 and R-7.

R-10 includes R-7, R-8, and R-12; and R-19 includes R-20.

Table 3

Incremental Costs Per Square Foot of Wall By Types of Increments

Group No.	Current Practice	MCS	Mean ($/ft²)	Standard Deviation ($/ft²)	Median ($/ft²)	Min.-Max. ($/ft²)	Sample Size
1	R-11 Type 21	R-19 Type 3	0.29	0.26	0.26	0-1.71	48
2	R-11 Type 21	R-24 Type 7	0.70	0.39	0.71	-0.42-1.88	29
6	R-11 Type 21	R-27 Type 7	0.74	0.31	0.78	0-1.39	18
3	R-11 Type 21	R-27 Type 1	0.87	0.40	0.94	0.24-1.51	20
4	R-11 Type 21	R-26 Type 12	0.68	0.03	0.68	0.63-0.70	4
5	R-11 Type 21	R-27 Type 2	1.03	0.34	0.93	0.86-1.30	3
8	R-11 Type 21	R-30 Type 2	0.64	0.13	0.61	0.51-0.82	4
7	R-11 Type 21	R-27 Type 6	0.87	0.23	0.90	0.48-1.15	6
9	R-19 Type 4	R-27 Type 6	0.32	0.28	0.26	-0.15-0.81	14
10	R-19 Type 4	R-31 Type 2	0.98	0.67	0.83	0.13-1.86	5
11	R-19 Type 4	R-38 Type 2	0.92	0.50	0.90	0.20-1.66	
All other cases of increments			0.89	0.86	0.72	-0.42-4.95	88

Wall Type Code

1 Strapped wall.
2 Double wall.
3 2x6, 24" o.c., advanced framing.
4 2x6, 24" o.c., standard framing.
5 2x6, 16" o.c., standard framing.
6 2x6, 24" o.c., foam outside.
7 2x6, 24" o.c., foam inside.
12 2x8, 16" o.c., standard framing.
19 2x6, 24" o.c., mod. advanced framing with foam outside.
21 2x4, 16" o.c., standard framing.

For current practice, Type 4 includes Type 5; R-11 includes R-13.

For MCS, Type 3 includes Types 4, 5, and 17; Type 6 includes Type 19; in group 2, R-24 includes R-25; in group 3, R-27 includes R-28; in group 9, R-27 includes R-25, R-26 and R-28; R-31 includes R-33 and R-34; and R-38 includes R-37, R-40, R-41 and R-43.

Table 4
Incremental Costs Per Square Foot of Window
By Types of Increments

Group No.	Current Practice	MCS	Mean ($/ft²)	Standard Deviation ($/ft²)	Median ($/ft²)	Min.-Max. ($/ft²)	Sample Size
1	DG* Type 1	TG** Type 1 TB	3.11	1.48	2.70	0.87- 7.30	41
2	DG Type 1 TB	TG Type 1 TB	2.28	1.53	2.66	0- 4.79	9
3	DG Type 2	TG Type 2	4.16	2.42	3.24	2.24- 9.77	10
4	DG Type 1	HM*** Type 10	3.55	2.48	3.48	1.10-10.26	17
5	DG Type 1	DG TB	2.61	1.38	2.34	0.68- 6.91	21
All other cases of increments			2.72	4.30	1.38	-6.03-22.55	66

Window Type Code

TB Thermal break.
1 Aluminum slider.
2 Wood slider.
4 Wood casement.
6 Wood Fixed.
7 Aluminum.
8 Wood.
9 Aluminum, thermal break.
10 Aluminum heat mirror.
12 Wood, awning.
14 Wood, double hung.

For current practice and MCS, Type 1 includes Types 7 and 9; Type 2 includes Types 4, 6, 8, 12, and 14.

* Double glazing.
** Triple glazing.
*** Heat mirror.

Table 5
Incremental Costs Per Square Foot of Door Barrier
By Types of Increments

Group No.	Current Practice	MCS	Mean ($/ft²)	Standard Deviation ($/ft²)	Median ($/ft²)	Min.-Max. ($/ft²)	Sample Size
1	Type 2	Type 1	3.70	3.78	3.38	-8.25-15.95	80
All other cases of increments			1.68	2.93	0.66	-0.57-16.53	140

Door Type Code

1 Insulated clad foam core.
2 Wood solid core.

Table 6
Incremental Costs Per Square Foot of Ceiling
By Types of Increments

Group No.	Current Practice	MCS	Mean ($/ft²)	Standard Deviation ($/ft²)	Median ($/ft²)	Min.-Max. ($/ft²)	Sample Size
1	R-30 Type 8	R-38 Type 1	0.44	0.26	0.39	0- 1.24	65
2	R-30 Type 8	R-49 Type 1	0.49	0.53	0.30	0.16- 2.40	17
3	R-30 Type 8	R-60 Type 1	0.63	0.14	0.58	0.53- 0.83	4
4	R-38 Type 8	R-38 Type 1	0.31	0.29	0.20	0- 1.34	25
5	R-38 Type 8	R-49 Type 1	0.30	0.09	0.28	0.16- 0.44	9
6	R-38 Type 8	R-60 Type 1	0.45	0.20	0.44	0.22- 0.79	10
7	R-30 Type 5	R-38 Type 5	0.26	0.27	0.21	0- 1.05	19
8	R-30 Type 5	R-38 Type 6	0.61	0.24	0.49	0.42- 1.04	10
9	R-30 Type 3	R-38 Type 2	0.44	0.15	0.38	0.30- 0.73	11
10	R-30 Type 3	R-38 Type 3	0.22	0.18	0.16	0.09- 0.56	6
11	R-30 Type 3	R-38 Type 1	0.43	0.24	0.33	0.28- 0.78	4
12	R-30 Type 8	R-38 Type 8	0.20	0.37	0.08	0.03- 1.57	16
All Other cases of increments			0.57	1.40	0.31	-0.57-12.40	83

Ceiling Insulation Type Code

1 Attic, advanced truss, loose-fill insulation.
2 Attic, advanced truss, batt insulation.
3 Attic, standard truss, baffle, compressed batt perimeter.
5 Vaulted, batt, no foam.
6 Vaulted, batt, foam inside.
8 Attic, standard truss, loose-fill insulation.

For MCS, R-49 includes R-50 and R-51; R-38 includes R-40, R-42, R-43, and R-44.

Table 7
Incremental Costs Per Square Foot of Air Infiltration Barrier By Types of Increments

Group No.	Current Practice	MCS	Mean ($/ft²)	Standard Deviation ($/ft²)	Median ($/ft²)	Min.-Max. ($/ft²)	Sample Size
1	Type 12,12,12	Type 2,2,2	0.08	0.05	0.10	0.02-0.15	5
2	Type 15, 1,15	Type 1,1,4	0.16	0.05	0.19	0.09-0.19	7
3	Type 15,12,15	Type 11,11,11	0.05	0.05	0.02	0.02-0.13	5
4	Type 15,12,15	Type 1,1,10	0.03	0.00	0.03	0.03-0.03	5
5	Type 15,12,15	Type 1,1,7	0.59	1.47	0.08	0-4.23	8
6	Type 15,12,15	Type 1,1,4	0.10	0.06	0.09	0.04-0.22	9
7	Type 15,15,15	Type 1,6,4	0.21	0.13	0.16	0.08-0.45	8
8	Type 15,15,15	Type 1,2,9	0.14	0.09	0.12	0.06-0.33	7
9	Type 15,15,15	Type 1,2,7	0.18	0.05	0.18	0.12-0.25	6
10	Type 15,15,15	Type 1,2,4	0.20	0.10	0.18	0.09-0.47	28
11	Type 15,15,15	Type 1,1,9	0.18	0.09	0.19	0.05-0.37	11
12	Type 15,15,15	Type 1,1,7	0.15	0.07	0.14	0.07-0.28	21
13	Type 15,15,15	Type 1,1,4	0.17	0.13	0.12	0.02-0.62	25
All Other cases of increments			0.21	0.17	0.17	0-1.27	98

Infiltration Barrier Type Code

1 Polyvinyl under sheetrock.
2 Foam.
4 Exterior plywood.
6 Polyvinyl between strapped wall.
7 Polyvinyl under slab floor.
9 #4 and #7.
10 Polyvinyl under subfloor.
11 Airtight drywall.
12 Craft or foil-faced insulation.
15 None.

Table 8
Incremental Costs Per Square Foot of Air-to-Air Heat Exchangers By Types of Increments

Group No.	Current Practice	MCS	Mean ($/ft²)	Standard Deviation ($/ft²)	Median ($/ft²)	Min.-Max. ($/ft²)	Sample Size
1	2	<1500 ft²	0.76	0.17	0.70	0.52-1.14	23
2	5	<1500 ft²	0.94	0.18	0.88	0.78-1.24	6
3	8	<1500 ft²	1.44	0.11	1.48	1.28-1.52	4
4	15	<1500 ft²	0.93	0.20	0.95	0.56-1.16	11
5	16	<1500 ft²	1.07	0.25	1.02	0.82-1.42	4
6	2	1500-2500 ft²	0.53	0.15	0.53	0.24-0.76	24
7	5	1500-2500 ft²	0.80	0.16	0.83	0.41-0.97	17
8	8	1500-2500 ft²	0.65	0.17	0.66	0.22-0.94	19
9	15	1500-2500 ft²	0.73	0.20	0.69	0.55-1.48	23
10	16	1500-2500 ft²	0.71	0.21	0.72	0.35-1.15	22
11	2	>2500 ft²	0.28	0.08	0.30	0.17-0.35	4
12	5	>2500 ft²	0.51	0.10	0.50	0.38-0.64	8
13	8	>2500 ft²	0.42	0.08	0.40	0.35-0.55	8
14	15	>2500 ft²	0.53	0.09	0.52	0.45-0.64	4
15	16	>2500 ft²	0.50	0.10	0.50	0.38-0.69	9
All Other cases of increments			0.78	0.27	0.75	0.29-2.08	95

AAHX Type Code

2 Airxchange (NuTone).
5 Conservation Energy Systems (VanEE).
8 DesChamps (200 Series).
15 Star Heat Exchanger 100A.
16 Star Heat Exchanger 200A.

Procedures for Calculating Energy Budget with a Heat Pump

Step 1 Determine the heating seasonal performance factor (HSPF) from the supplier, contractor, or manufacturer of the heat pump. The Air Conditioning Refrigeration Institute (ARI) has a directory listing HSPF's for most heat pumps.

Tip: Try to find the most efficient model.

Step 2 Heat Pump Energy Budget = $\dfrac{\text{Energy Budget}}{\dfrac{\text{HSPF}}{3.413}\ (.75)}$

Step 3 Indicate the heat pump energy budget and the HSPF of that heat pump on the WATTSUN printout.

Step 4 If the heat pump energy budget is less than or equal to the Super Good Cents energy budget specifications, the home meets Super Good Cents specifications.

Tip: Remember Super Good Cents specifications call for all ductwork in unheated space to be insulated to R-11 (3-1/2" of fiberglass batt).

Bibliography

These resources were instrumental in the development of WATTSUN Version 3.1.

"A Simplified Method for Determining Below-Grade Heat Loss." Danny S. Parker. Northwest Power Planning Council. Helena, MT. 1985.

Conversations with Jeff Harris of Bonneville Power Administration. June through November 1985.

Handbook of Fundamentals. American Society of Heating Refrigeration and Air Conditioning. 1985.

The Model Conservation Standard Energy Budget Approach Handbook. Washington State Energy Office, Ecotope, and Bonneville Power Administration. January 1984.

Watt-Sun. Volume 1 User Manual. Washington State Energy Office. March 1984.

Summary of Commands

WATTSUN 3.1 Commands for Data Entry

(ESC)	Takes you back to previous screen.
(↵)	Carriage Return.
(E)	To edit data (help mode only).
(T)	To input type of construction.
(A)	To input area of component.
(C)	To input cost of component.
(HOME)	Switches between "current" and "proposed."
(PG UP)	Page up to check first 10 options in Component Menu.
(PG DN)	Page down to check second 10 options in Component Menu.
(↑)	Scrolls up to previous component type.
(↓)	Scrolls down to next component type.
(*)	Deletes type, area, and cost.
(←)	Backspace key.
(⇧)	Shift key.
(CAPS LOCK)	Cap lock key.

For convenient duplication, the Building Component Worksheet and the Input Worksheet are located in the back pocket of this binder.

WATTSUN 3.1
BUILDING COMPONENT WORKSHEET

HOUSE I.D.:_____

MENU NO.	BUILDING COMPONENT	BUILDING STANDARD	COMPONENT DESCRIPTION	AREA/LF	COST TOTAL	INCREMENTAL COST $/UNIT
1	Below Grade Basement	Current				
		Proposed				
2	Slab On Grade	Current				
		Proposed				
3	Crawl Space	Current				
		Proposed				
4	Above Grade Walls	Current				
		Proposed				
		Current				
		Proposed				
		Current				
		Proposed				
5	Windows	Current	TOTAL AREA / S / SE / E / NE / N / NW / W			
		Proposed				
6	Exterior Doors	Current				
		Proposed				
7	Skylights	Current				
		Proposed				
8	Ceiling	Current				
		Proposed				
		Current				
		Proposed				
9	Infil-tration	Current				
		Proposed				
0	Thermal Mass	Current				
		Proposed				

NOTES

WATTSUN 3.1
INPUT WORKSHEET

HOUSE I.D.:_____

MAIN MENU NO.			
1	1) House Identification: _____ 2) Address (site): _____ 3) Builder's Name: _____ 4) Homeowner's Name: _____ 5) Utility's Name: _____ 6) Analyst's Name: _____		
2	**See Building Component Worksheet**		
3	**Heated Floor Area** (including basement and upstairs): _____ Ft^2		
4	**Location** (choose location from table in Section II): _____		
5	**See Building Component Worksheet** (window solar orientation)		
6	**Economics**	**Current**	**Proposed**
	1) Base House Cost:	$ _____	$ _____
	2) Other Costs:	$ _____	$ _____
	3) Builder Mark-up:	_____ %	_____ %
	4) Interest Rate:	_____ %	_____ %
	5) Mortgage Term:	_____ Yrs.	_____ Yrs.
	6) Down Payment:	_____ %	_____ %
	7) Income Tax Bracket:	_____ %	_____ %
	8) Real Estate Tax:	_____ %	_____ %
	9) Insurance:	_____ %	_____ %
	10) Cost Per kWh:	$ _____	$ _____
7		**Current**	**Proposed**
	1) **Heating Systems** (describe):	_____	_____
	2) **Cost:**	$ _____	$ _____
	3) Ductwork In Unheated Space—		
	Insulation R-values:	_____	_____
	Btu/hr F° (Table B):	_____	_____
	4) **Indoor Thermostat Setpoint:**	_____ F°	_____ F°
	5) **Outside Winter Design Temperature:**	_____ F°	_____ F°

TABLE A

DUCT SIZE	DUCT FT^2 PER LF	INSULATION R-VALUE			
		R-2	R-4	R-7	R-11
5" dia.	1.31	0.66	0.33	0.19	0.12
6" dia.	1.57	0.79	0.39	0.22	0.14
7" dia.	1.83	0.92	0.46	0.26	0.17
8" dia.	2.09	1.05	0.52	0.30	0.19
10" dia.	2.62	1.31	0.66	0.37	0.24
12" dia.	3.14	1.57	0.79	0.45	0.29
14" dia.	3.66	1.83	0.92	0.52	0.33
8"x12"	4.67	2.34	1.17	0.67	0.42
10"x20"	5.0	2.50	1.25	0.71	0.45
20"x20"	6.67	3.34	1.67	0.95	0.61

TABLE B
Duct Heat Loss Calculation

DUCT RUN	LINEAL FEET	TABLE A VALUE	= HEAT LOSS BTU/HR F°
1	x		=
2	x		=
3	x		=
SUM LINES 1, 2, 3— TOTAL DUCT LOSS:			=

Refer to "Duct Heat Loss", Section IV, for instuctions in the use of Tables A and B.